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Human Views

Extensions to the Department of Defense Architecture Framework

Kevin Baker, Andrew Stewart,
Chris Pogue, and Rudy Ramotar
CAE Professional Services (Canada) Limited

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Abstract

The Collaborative Capability Definition, Engineering and Management (CapDEM) Technology Demonstration Project (TDP) has been exploring the concept of Capability Engineering (CE) which provides analytical rigour and traceability within a “System-of-Systems (S-of-S)” construct to support the execution of Capability Based Planning (CBP). CapDEM has invested significant effort into the integration of specific tools and processes to support CE and its relationship to the Defence Management System. Within this effort, the utility of the Department of Defense Architecture Framework (DoDAF) has been highlighted. Specifically, DoDAF assists the overall system design, evolutionary acquisition and interoperability within the US Joint Capabilities Integration and Development System (JCIDS), which is used to determine military capability requirements.

A component of a capability that has increasingly drawn attention within the CapDEM team is how best to represent the human aspect of a capability within the S-of-S construct. DoDAF also has been recognized as lacking a suitably dominant human perspective. To that end, the concept of Human Views (HVs), which leverage Human System Integration (HSI) principles, has emerged.

The activities and results presented in this report have progressed to ensure that Capability Engineering adequately addresses the people component in both method and substance. In this respect, the following activities have been completed:

1. A subset of Human Views, addressing the manpower, career progression, and training domains, have been developed as a 'test case' thereby demonstrating where they fit in CE and generally how they support decision making within CBP at the program/capability level;

2. A direct relationship to an on-going Human Resources (HR)-related activity (Military Occupation Structure Analysis, Redesign and Tailoring [MOSART]) has been established; and

3. An application of the Human Views to a military system acquisition (Multi-Mission Effects Vehicle [MMEV]) has been explored.

The outcome of this effort demonstrates that HVs do indeed ‘work’ as they fit with the current US JCIDS framework and therefore should theoretically fit within the DND acquisition process. In addition, HVs provide a suitable mechanism to embed HSI into CP-based decision making and ensure a significant cost driver is addressed ‘up front’.

Résumé

Le Projet de démonstration de technologie (PDT) intitulé « Définition, ingénierie et gestion collaborative de capacités » (DIGCap) a examiné le concept d'ingénierie des capacités (IC), qui apporte rigueur analytique et traçabilité à la notion de « système de systèmes » (S de S) afin d'appuyer la planification fondée sur les capacités (PFC). Le DIGCap a investi beaucoup d'efforts dans l'intégration d'outils et de processus particuliers pour appuyer l'IC et sa relation avec le Système de gestion de la Défense. Dans le cadre de cette initiative, l'utilité du Cadre d'architecture du département de la Défense des États Unis (DoDAF) a été soulignée. En particulier, le DoDAF appuie la conception globale, l'acquisition évolutive et l'interopérabilité des systèmes au sein du Système d'intégration et de développement des moyens interarmées (JCIDS) des États Unis, qui est utilisé pour établir les besoins en capacités militaires.

Ce qui intéresse de plus en plus l'équipe DIGCap, c'est de trouver le meilleur moyen de représenter l'aspect humain d'une capacité dans un S de S. L'équipe a également constaté que le DoDAF n'accorde pas la priorité à l'aspect humain. C'est pourquoi le concept de « vue humaine » (VH), qui fait appel aux principes de l'intégration homme machine (IHM), a émergé.

Les activités et les résultats présentés dans ce rapport initial ont été développés pour faire en sorte que l'ingénierie des capacités (IC) tienne compte adéquatement de l'élément humain dans ses méthodes et sa substance. À cet égard, les activités suivantes ont été menées à bien :

1. Un sous-ensemble de vues humaines (VH) portant sur la main d'œuvre, l'avancement professionnel et l'instruction a été élaboré pour servir de « cas type » et démontrer comment les VH sont utiles à l'IC et comment elles appuient, d'une façon générale, le processus de prise de décision lié à la PFC au niveau des programmes et des capacités.

2. Une relation directe avec une activité liée aux Ressources Humaines (RH) (Projet d'analyse, de restructuration et d'adaptation de la structure des groupes professionnels militaires [PARA]) a été établie.

3. Une application des VH à l'acquisition d'un système militaire (véhicules à effet multimission [VEMM]) a été examinée.

Le résultat de ces efforts montre que les VH « fonctionnent » réellement, car elles s'inscrivent parfaitement dans le cadre actuel du JCIDS des Etats-Unis. Par conséquent, en théorie, elles devraient bien s'intégrer au processus d'acquisition du MDN. De plus, les VH fournissent un mécanisme approprié pour intégrer l'IHM au processus de prise de décision lié à la PFC, et faire en sorte qu'un important « inducteur de coût » soit pris en considération.

Executive summary

Human Views: Extensions to the Department of Defense Architecture Framework

Kevin Baker; Andrew Stewart; Chris Pogue; Rudy Ramotar; DRDC Corporate CR 2008-001; Defence R&D Canada – Corporate; September 2008.

Introduction or background: With the adoption of Capability Based Planning (CBP), the Canadian Forces (CF) initiated a migration away from platform-centric solutions to capability-based solutions. Capability Engineering (CE) is aimed at providing engineering rigour to the development of a capability within a Systems-of-Systems (S-of-S) construct. CE is also intended to ensure a systematic link between the conceptualization of a capability and the definition of component systems and functions. A capability is defined as the "ability to achieve a desired effect in a given environment within a specified time, and sustain that effect for a designated period". In turn, this 'ability' is generated when the following components are delivered: people, organization, doctrine, training, materiel, logistics, infrastructure, and information.

A key aspect of CE is the development and use of an architecture framework. Architecture is defined as "the structure of components, their interrelationships, and the principles and guidelines governing their design and evolution over time". While several architecture frameworks currently exist, development of the CE approach within the Canadian Defence context has leveraged the Department of Defense Architecture Framework (DoDAF). DoDAF utilizes a combination of graphic displays or Views to describe and support overall system design, evolutionary acquisition and interoperability. The focus of the existing DoDAF views is to provide support to the more traditional Systems Engineering domain and extend these processes to the S-of-S construct. Specifically, DoDAF assists the overall system design, evolutionary acquisition and interoperability within the US Joint Capabilities Integration and Development System (JCIDS), which is used to determine military capability requirements. DoDAF is an integrated architecture whereby common points of reference link together architecture data elements thereby ensuring relationships between the architecture data products and views.

The human element of a capability has drawn increasing attention resulting in efforts to determine how best to represent this element within the S-of-S construct. An attempt has been made within DoDAF to represent humans through "human supplements" based on the Human Systems Integration (HSI) domains: Manpower/Personnel, Human Factors Engineering, Training, Health Hazards, and System Safety. These domains collectively define how the human component will impact system or capability performance and vice versa. Collectively, the proposed DoDAF human supplements appear insufficient to adequately define, develop, and execute an overall capability program at the S-of-S level in supporting the full breadth of HSI. In response, a series of Human Views (HVs) are proposed.

Results: Four HVs contained herein have been designed to address a subset of the overall HSI framework, specifically, Manpower, Training, and Career Progression. The HVs are built on a foundation of competencies (e.g., knowledge, skills, and abilities). Training is based on increasing competencies among military personnel; recruitment identifies and fills gaps in

competencies; career progression is based on advancing individuals' competencies to satisfy the job requirements; and inventories demonstrate the current competencies.

The proposed HVs were conceptually integrated in the US JCIDS to illustrate their utility within different phases of a defence acquisition strategy. Similarly, the HVs were applied to a notional use case, Multi-Mission Effects Vehicle (MMEV). The aim was to depict the application of the HVs to help address issues surrounding Manpower, Career Progression, and Training accompanying the acquisition and subsequent fielding of the MMEV. From a holistic standpoint, this involves comparing Human Views for the existing CF force structure (AS-IS state) against a future CF force structure with the MMEV (TO-BE state).

Significance: The conceptual approach to developing Human Views to improve visibility of the 'human' aspect of a capability within Capability Engineering was first introduced as part of the HV Concept Paper. The report served as a departure point for subsequent development. As an extension to this original HV work, the activities and results presented in this report have progressed to ensure that CE adequately addresses the people component in both method and substance. In this respect, a subset of Human Views has been developed as a 'test case' thereby demonstrating where they fit in CE and DoDAF, and generally how they support decision making within CBP at the program and capability levels.

HVs facilitate the linkage and transfer of information between systems engineers and architects developing investment options at the capability level, and the strategic HSI analysts who assess and predict implications. Given the complexity inherent in S-of-S relationships, the lack of well defined and universally accepted HVs linked to DoDAF views limits the ability to address key HSI issues at the capability level. The outcome of this effort demonstrates that Human Views provide a suitable mechanism to embed HSI into CBP decision making and ensure a significant cost driver is addressed up front.

Future plans: Continued investigation of Human Views requires follow on work to:

1. Introduce newly updated DoDAF to Directorate of Capability Planning to assess whether it can be used as intended;

2. Map HVs to acquisition processes within DND (similar to JCIDS mapping);

3. Explore tools to directly support the creation of HVs;

4. Assess HVs for Force Development by CFD to embed personnel related fields;

5. Extend HVs to include additional architecture data products to address other human elements (HV Concept Paper proposed other HVs); and

6. Collaborate with the international community to explore compatibility with similar HV research being conducted in the US and UK.

Sommaire

Vues humaines : Nouvel élément du Cadre d'architecture du département de la Défense

Kevin Baker; Andrew Stewart; Chris Pogue; Rudy Ramotar; RDDC – Services généraux CR 2008-001; Recherche et développement pour la défense Canada – Services généraux; Septembre 2008.

Introduction ou contexte: En adoptant la planification fondée sur les capacités (PFC), les Forces canadiennes (FC) ont abandonné les solutions axées sur les plateformes en faveur des solutions axées sur les capacités. L’ingénierie des capacités (IC) vise à intégrer la rigueur de l’ingénierie au développement de capacités dans le cadre d’un système de systèmes (S de S). L’IC vise également à établir un lien systématique entre la conceptualisation d’une capacité et la définition de ses systèmes et de ses fonctions. Une capacité est définie comme « un moyen de produire l’effet recherché dans un environnement donné et dans un délai précis, et de soutenir cet effet pendant une période déterminée ». Cette « capacité » est obtenue lorsque les éléments suivants sont réunis : personnel, organisation, doctrine, instruction, matériel, logistique, infrastructure et information.

L’un des principaux aspects de l’IC est le développement et l’utilisation d’un cadre d’architecture. L’architecture est définie comme « la structure des différents éléments d’un système, leurs interconnexions, et les principes qui régissent leur conception et leur évolution ». Plusieurs cadres d’architecture existent actuellement, mais pour l’IC dans le contexte des Forces canadiennes, on utilise le Cadre d’architecture du département de la Défense des États Unis (DoDAF). Le DoDAF utilise une combinaison d’écrans graphiques, ou « vues », pour décrire et appuyer la conception globale, l’acquisition évolutive et l’interopérabilité des systèmes. Les vues existantes du DoDAF sont centrées sur les domaines traditionnels de l’ingénierie des systèmes, et elles peuvent s’appliquer aux S de S. En particulier, le DoDAF appuie la conception globale, l’acquisition évolutive et l’interopérabilité des systèmes au sein du Système d’intégration et de développement des moyens interarmées (JCIDS) des États Unis, qui est utilisé pour établir les besoins en capacités militaires. Le DoDAF est un cadre d’architecture intégré dans lequel des points de référence communs relient entre eux les différents éléments de données de l’architecture, ce qui permet d’établir des relations entre les données et les vues.

L’élément humain des capacités suscite de plus en plus d’intérêt, et c’est pourquoi des efforts ont été déployés pour déterminer le meilleur moyen de représenter cet élément dans un S de S. Une tentative a été faite, dans le cadre du DoDAF, pour représenter l’élément humain par des « compléments humains » fondés sur les différents domaines de l’intégration homme machine (IHM) : main d’œuvre/personnel, ergonomie, instruction, risques pour la santé, et sécurité des systèmes. Ces domaines définissent collectivement quel sera l’impact de l’élément humain sur la performance du système ou de la capacité, et vice versa. Collectivement, les compléments humains proposés pour le DoDAF semblent insuffisants pour définir, développer et exécuter efficacement le programme de capacités général au niveau d’un S de S en utilisant toutes les possibilités de l’IHM. C’est pourquoi une série de vues humaines (VH) ont été proposées.

Résultats: Les quatre VH proposées dans le rapport constituent un sous ensemble du cadre général de l'IHM : elles portent sur la main d'œuvre, l'instruction et l'avancement professionnel. Ces VH sont centrées sur les compétences professionnelles (connaissances, habiletés et aptitudes). L'instruction vise à augmenter les compétences du personnel militaire; le recrutement détecte et corrige les lacunes dans les compétences; l'avancement professionnel est fondé sur l'augmentation des compétences des militaires pour répondre aux exigences du service; et les répertoires font état des compétences actuelles.

Les VH proposées ont été intégrées de façon conceptuelle au JCIDS des États Unis pour démontrer leur utilité dans les différentes phases de la stratégie d'acquisition de la Défense. De la même façon, les VH ont été appliquées à l'acquisition d'un système militaire : le véhicule à effet multimission (VEMM). L'objectif était de dépeindre l'application des VH aux problèmes de main d'œuvre, d'avancement professionnel et d'instruction liés à l'acquisition et à la mise en service du VEMM. D'un point de vue holistique, cela consiste à comparer les VH de la structure de forces existante (état actuel) et de la structure qui sera obtenue avec les VEMM (état final).

Portée: L'idée de développer des vues humaines (VH) pour améliorer la visibilité de l'aspect humain des capacités dans le cadre de l'IC a été proposée initialement dans le document conceptuel sur les VH. Ce document a servi de point de départ pour les travaux de développement subséquents. Les activités et les résultats présentés dans ce rapport initial ont été développés pour faire en sorte que l'ingénierie des capacités (IC) tienne compte adéquatement de l'élément humain dans ses méthodes et sa substance. À cet égard, un sous ensemble de VH a été élaboré pour servir de « cas type » et démontrer comment les VH sont utiles à l'IC et au DoDAF, et comment elles appuient, d'une façon générale, le processus de prise de décision lié à la PFC au niveau des programmes et des capacités.

Les VH facilitent les relations et le transfert d'informations entre les ingénieurs/concepteurs de systèmes qui élaborent des options d'investissement au niveau des capacités, et les analystes de l'IHM stratégique qui évaluent et prédisent les implications. Étant donné la complexité inhérente aux relations dans les S de S, l'absence de VH bien définies et universellement reconnues liées au DoDAF limite la capacité d'examiner les principaux problèmes d'IHM au niveau des capacités. Le résultat des efforts qui ont été déployés est le suivant : les VH fournissent un mécanisme approprié pour intégrer l'IHM au processus de prise de décision lié à la PFC, et faire en sorte qu'un important « inducteur de coût » soit pris en considération.

Perspectives: Pour poursuivre les recherches sur les vues humaines (VH), il faudra :

1. Installer la nouvelle version du DoDAF dans la Direction de la planification des activités, pour voir si elle fonctionne comme prévu.

2. Adapter les VH aux processus d'acquisition du MDN (comme dans le JCIDS).

3. Trouver des outils qui appuient directement la création de VH.

4. Évaluer les VH pour les besoins du développement des forces par le CFD, afin d'intégrer les domaines liés au personnel.

5. Étendre la notion de VH à d'autres éléments de données de l'architecture, pour couvrir d'autres facteurs humains (le document conceptuel sur les VH propose d'autres VH).

6. Collaborer avec la communauté internationale pour examiner la compatibilité de nos recherches sur les VH avec les travaux de recherche similaires menés aux États Unis et au Royaume Uni.

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Table of contents

Abstract …….. i

Résumé …..... ii

Executive summary iii

Sommaire v

Table of contents ix

List of figures xii

List of tables xiii

1 Introduction 1

1.1 Background 1

1.2 Objective 2

1.3 This Document 2

2 Background 4

2.1 General 4

2.2 Capability Engineering 4

2.2.1 Overview 4

2.2.2 Role of Architecture – Extending the Construct 5

2.2.3 Capability Engineering – Conceptual Application 5

2.3 DoD Architecture Framework 6

2.3.1 Overview 6

2.3.2 DoDAF Views 7

2.3.3 Architecture Data Products 7

2.3.4 Architecture Data Elements 7

2.4 Extensions to DoDAF 8

2.4.1 MoD Architecture Framework 8

2.4.2 DND Architecture Framework 9

3 Human Views Architecture Products 10

3.1 General 10

3.2 Manpower Projections (HV-1) 12

3.2.1 Product Description 12

3.2.1.1 Product Definition 12

3.2.1.2 Product Purpose 12

3.2.1.3 Product Detailed Description 13

3.2.1.4 Product Contribution 16

3.2.2 Product Data Element Definition 16

3.3 Career Progression Roadmap (HV-2) 17

3.3.1 Product Description 17

3.3.1.1 Product Definition 17

3.3.1.2 Product Purpose ... 17
3.3.1.3 Product Detailed Description ... 17
3.3.1.4 Product Contribution ... 20
3.3.2 Product Data Element Definition ... 21
3.3.3 Example ... 23
3.4 Individual Training Roadmap (HV-3) ... 25
3.4.1 Product Description ... 25
3.4.1.1 Product Definition ... 25
3.4.1.2 Product Purpose ... 25
3.4.1.3 Product Detailed Description ... 25
3.4.1.4 Product Contribution ... 26
3.4.2 Product Data Element Definition ... 27
3.4.3 Example ... 29
3.5 Establishment Inventory (HV-4) ... 30
3.5.1 Product Description ... 30
3.5.1.1 Product Definition ... 30
3.5.1.2 Product Purpose ... 30
3.5.1.3 Product Detailed Description ... 31
3.5.1.4 Product Contribution ... 32
3.5.2 Product Data Element Definition ... 32
4 Linking Human Views to DoDAF ... 34
4.1 General ... 34
4.2 Linkages Among Views ... 35
4.3 Relationships Between Architecture Products ... 35
4.4 Relationships Between Architecture Data Elements ... 38
5 Application of Human Views ... 41
5.1 General ... 41
5.2 JCIDS Methodology ... 41
5.2.1 JCIDS Analysis ... 42
5.2.2 JCIDS Documentation ... 43
5.2.3 Analysis of Alternatives (AOA) ... 43
5.3 Application of Architecture Products ... 44
5.3.1 Overview ... 44
5.3.2 JCIDS Analysis ... 45
5.3.2.1 Functional Area Analysis ... 46
5.3.2.2 Functional Needs Analysis ... 46
5.3.2.3 Functional Solution Analysis ... 46
5.3.2.4 Post Independent Analysis ... 47
5.3.3 JCIDS Documentation ... 47
5.3.3.1 Joint Capabilities Document ... 47
5.3.3.2 Initial Capabilities Document (ICD) ... 47

5.3.3.3 Capability Development Document 47
5.3.3.4 Capability Production Document 48
5.3.4 Analysis of Alternatives 48
6 Multi-Mission Effects Vehicle Use Case 49
6.1 Background 49
6.2 Results of the MMEV Study 50
6.3 Problem Space 52
6.4 Solving the Problem 55
6.4.1 General 55
6.4.2 Manpower 55
6.4.3 Career Progression 57
6.4.4 Training 62
7 Conclusions and Next Steps 67
7.1 Initial HV Work 67
7.2 Current HV Work 67
7.3 Future HV Work 68
References 69
List of symbols/abbreviations/acronyms/initialisms 73
Distribution list 77

List of figures

Figure 1: Capability Engineering Representation ... 5
Figure 2: DoD Architecture Framework Version 1.5 ... 6
Figure 3: MoDAF Viewpoints (MoD, 2008) ... 8
Figure 4: DNDAF Views (DEA, 2007) ... 9
Figure 5: Human Systems Integration Domain ... 10
Figure 6: CF Capability Hierarchy ... 14
Figure 7: Manpower Projections (HV-1) ... 15
Figure 8: CF Military Occupational Structure ... 18
Figure 9: Career Progression Roadmap (HV-2) ... 20
Figure 10: Armoured Crewman (MOSID 00005) Career Progression Roadmap (HV-2) ... 24
Figure 11: Individual Training Roadmap (HV-3) ... 26
Figure 12: Armoured Officer (MOSID 00178) Individual Training Roadmap (HV-3) ... 29
Figure 13: Establishment Inventory (HV-4) ... 32
Figure 14: Extending DoDAF with Human Views ... 34
Figure 15: Linkages Among DoDAF Views and Human Views ... 35
Figure 16: Relationships Between DoDAF and Human Views Architecture Products ... 37
Figure 17: DoDAF Classes and Relationships (Vitech, 2007) ... 38
Figure 18: DoDAF and Human View Element Relationships ... 39
Figure 19: Class Relationship Matrix ... 40
Figure 20: JCIDS Process (DoD, n.d.) ... 42
Figure 21: MMEV Functional Decomposition ... 51
Figure 22 : MMEV Transformation ... 53
Figure 23: Combat Team Mechanized Infantry Transformation ... 54
Figure 24: Notional HV-1 MMEV Architecture Data Product ... 56
Figure 25: HV-2 Architecture Data Product for Field Artilleryman (AS-IS) ... 58
Figure 26: HV-2 Architecture Data Product for Artillery Officer (AS-IS) ... 59
Figure 27: Comparing MMEV Troop Leader Competencies to Existing Jobs ... 60
Figure 28: HV-3 Architecture Data Product for Armoured Officer (AS-IS) ... 63
Figure 29: HV-3 Architecture Data Product for Armoured Crewman (AS-IS) ... 64

List of tables

Table 1: Data Element Definitions for Manpower Projections (HV-1). 16
Table 2: Data Element Definitions for Career Progression Roadmap (HV-2). 21
Table 3: Data Element Definitions for Individual Training Roadmap (HV-3). 27
Table 4: Data Element Definitions for Establishment Inventory (HV-4)..................................... 33
Table 5: Mapping DoDAF Architecture Products to JCIDS 44
Table 6: Combat Arms Career Field.. 52
Table 7: Armoured and Artillery Officer Tasks Pertinent to MMEV Troop Leader. 61
Table 8 : MMEV Troop Leader Train/No Train Matrix.. 65

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1 Introduction

1.1 Background

The Collaborative Capability Definition, Engineering and Management (CapDEM) Technology Demonstration Project (TDP) has been exploring the concept of Capability Engineering (CE) which provides analytical rigour and traceability within a "System-of-Systems (S-of-S)" construct to support the execution of Capability Based Planning (CBP). CapDEM has invested significant effort into the integration of specific tools and processes to support CE and its relationship to the Defence Management System. Within this effort, the utility of the Department of Defense Architecture Framework (DoDAF) has been highlighted (DoD, 2007a, 2007b). Currently, DoDAF is used within the US Joint Capabilities Integration and Development System (JCIDS) (CJSCI, 2007; CJSCM, 2007) to determine military capability requirements. Several initiatives within the Department of Defence (DND) have progressed using this framework and the product and associated informational structure has proven itself to be quite valuable. Within the DND, the Assistant Deputy Minister (Information Management) (ADM(IM))/Directorate of Enterprise Architecture (DEA) recently published a DND Architectural Framework (DNDAF) which includes additional views to address gaps identified in DoDAF (e.g., IT and security) (DEA, 2007). Similarly, the Ministry of Defence (MoD) has created the MoD Architecture Framework (MoDAF) which most notably incorporates a series of Strategic and Acquisition Views with DoDAF (MoD, 2008).

DoDAF/DNDAF (DoD, 2007a, 2007b; DEA, 2007) utilizes a combination of graphic displays or Views to describe and support overall system design, evolutionary acquisition, and interoperability. Operational Views (OVs) represent tasks or activities that need to be accomplished and identify the various organizations and the information flow involved in performing these activities. System and Services Views (SVs) represent the systems and services that will support operations and their functional characteristics. Technical Standards Views (TVs) identify which standards govern system implementation.[1] The focus of the OVs and SVs that are produced in accordance with the conduct of a DoDAF development exercise provides considerable support to the more traditional Systems Engineering domain and extends these processes to S-of-S constructs. These views, which may be altered and extended to support DND/Canadian Forces (CF) specific requirements, will become elemental to the analytical landscape for the CE process.

An element of a capability that has increasingly drawn attention within the CapDEM team is how best to represent the human aspect of a capability within the "S-of-S" construct. DoDAF has also been recognized as lacking a suitably dominant human perspective (Pogue, Baker, & Pagotto, 2005; Baker et. al., 2006). To that end, the idea of Human Views (HVs), which leverage Human System Integration (HSI) principles, has emerged.

A conceptual notion of HVs within the DoDAF specifically targeted for the CF was first proposed and articulated in a HV Concept Paper (Pogue, Baker, & Pagotto, 2005). A follow-on workshop with representatives from DRDC, Chief of Military Personnel (CMP), and Military Occupation

[1] All Views (AV) products capture the overarching aspects of the architecture that are related to the OVs, SVs, and TVs. The AV products do not represent a distinct view of the architecture.

Structure Analysis, Redesign and Tailoring (MOSART) project[2] determined the inherent value of embedding HSI concepts into the Capability Engineering program. Subsequent interaction with the MOSART project resulted in what appears to be a suitable data structure format to which HVs might align, and discussions with CMP suggest that there is a key relationship between the output of the conceptual phase of an HSI program and the input requirements of DND staffing and personnel development programs (i.e., Military Human Resources [HR] system) which are integral components of the Capability Based decision making process. Although the HV Concept Paper (Pogue, Baker, & Pagotto, 2005) identified several potential HV architecture products, this effort focuses on a subset that most readily addresses key HSI decision making requirements with respect to the introduction of a new capability.

1.2 Objective

The overall objective of this report is to present an extension to the existing DoDAF[3] in the form of a limited set of Human Views architecture products that specifically assist decision makers interested in the HSI issues related to Manpower, Career Progression, and Training. This work is a continuation of the HVs concept exploration that began during the fall of 2005 which resulted in a Concept Paper (Pogue, Baker, & Pagotto, 2005) and follow-on workshop with key stakeholders.

1.3 This Document

This section outlines the background and states the objectives of this report. The report outline in this section is intended to demonstrate the relationship between the other sections and to guide the reader in finding sections of interest within the document. In addition are the following sections:

1. Section Two provides background information as well as a common understanding of pertinent terminology related to DoDAF and Human Views;

2. Section Three describes the four HV architecture products to address the areas of Manpower, Career Progression, and Training;

3. Section Four outlines the linkages between Human Views and the existing DoDAF architecture products;

4. Section Five documents the application of Human Views to support an acquisition process such as the JCIDS;

[2] The MOSART project existed at the time of the study, but the project has since been re-integrated into Director Personnel Generation Requirements (DPGR). As such, concepts originating from the MOSART project may not continue to progress beyond this point.

[3] Since DNDAF was not formally released when commencing this project coupled with the commonality between DoDAF and DNDAF, the current HV development effort focused on linking the HV architecture data products with DoDAF as opposed to DNDAF. The HVs could be similarly linked to DNDAF since the ‘hooks’ to the underlying data model described in later sections are similar across both architecture frameworks.

5. Section Six details the Multi Mission Effects Vehicle (MMEV) use case and the contribution of Human Views to assist decision-makers; and

6. Section Seven articulates conclusions as well as recommendations for future work to continue extending DoDAF with respect to integrating the Personnel domain.

2 Background

2.1 General

Capability Engineering and the DoD Architecture Framework provide the foundation for the Human Views effort articulated in this report. As such, the following sections provide background information as well as common definitions of pertinent terminology related to these two areas.

2.2 Capability Engineering

2.2.1 Overview

A capability is defined as the "ability to achieve a desired effect in a given environment within a specified time, and sustain that effect for a designated period" (DPM, 2005). In turn, this 'ability' is generated when the following components are delivered: people, organization, doctrine, training, materiel, logistics, infrastructure, and information.

CE is a proposed concept to support CBP by providing engineering rigour to the development of a capability within a S-of-S construct. CE is also intended to ensure a systematic link between the conceptualization of a capability and the definition of component systems and functions. With the adoption of CBP, the DND/CF migrated away from platform-centric solutions to capability-based solutions. In turn, this demands a more complete view of a S-of-S and the associated components that enable a capability.

CE represents the nexus of a defence acquisition approach that considers a holistic lifespan perspective, incorporates portfolio management principles (multiple, integrated projects and programs), and employs Systems Engineering concepts extended to a S-of-S as depicted in Figure 1. The complexity of S-of-S, both in terms of their inherent characteristics and dynamic relationships, influence the development and management of a military capability. In fact, the nature of the various S-of-S relationships typically exceeds the operational mandate of any single organization in terms of definition, development, and operational implementation. As such, these relationships must be addressed at the capability level which in turn drives the requirements for a CE approach to support a Capability Management framework (Pagotto and Walker, 2004). In managing this complexity, an overarching, common and integrated architectural framework provides broad visibility while capturing operational and system characteristics.

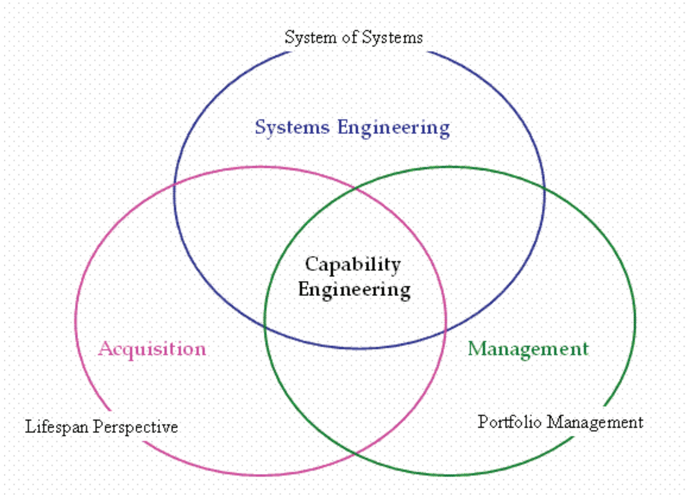

Figure 1: Capability Engineering Representation

2.2.2 Role of Architecture – Extending the Construct

A key aspect of Capability Engineering is the development and use of an architecture framework:

1. To establish a "common language" between diverse stakeholders;

2. To manage the inherent complexity of S-of-S, particularly under the influence of diverse mission requirements; and

3. To enable incremental capability development and integration into the force structure.

Architecture is defined as "the structure of components, their interrelationships, and the principles and guidelines governing their design and evolution over time" (IEEE, 1990). In turn, architectures serve to manage complexity and incremental change while providing universal terminology for communication amongst diverse stakeholders.

While several architecture frameworks currently exist (DoD, 2007a, 2007b; DEA, 2007; MoD, 2008), development of the Capability Engineering approach within the Canadian Defence context has leveraged the DoDAF 'views' (DoD, 2007a, 2007b). These views support overall system design, evolutionary acquisition, and interoperability within the US JCIDS (CJSCI, 2007; CJSCM, 2007), which is used to determine military capability requirements.

2.2.3 Capability Engineering – Conceptual Application

The application of CE to Capability-Based Planning will typically commence by developing architectures for core capability areas (e.g., Command and Control [C2]) in accordance with strategic defence guidance documents. This establishes clear, traceable links to high-level strategic guidance and defence policy. These representations of defence capabilities are used to generate a comprehensive compilation of "architecture views" that detail the operational, system, and technical perspectives of the capability at various layers of resolution depending on what type of decisions are required. The modelled capability is applied against the various planning scenarios and task lists to assess the AS-IS capability configuration against a desired target capability (modelling the target capability into a suitably comparable architecture views serves as a TO-BE end state). Capability metrics can then be used to identify capability gaps that must be addressed to achieve transformation. Options for resolving capability gaps can be analyzed seeking an optimized blend of capability components. Once the most appropriate program for addressing capability gaps has been determined, the resulting plan constitutes a Capability Roadmap and resource strategy that is both agile and responsive to evolving Strategic Defence directives.

2.3 DoD Architecture Framework

2.3.1 Overview

Understanding DoDAF is a necessary prerequisite to better comprehend the rationale for the design and integration of the HV architecture products. Figure 2 illustrates the DoDAF components whereby views group together one or more architecture data products and each architecture data product is composed of finite data elements.

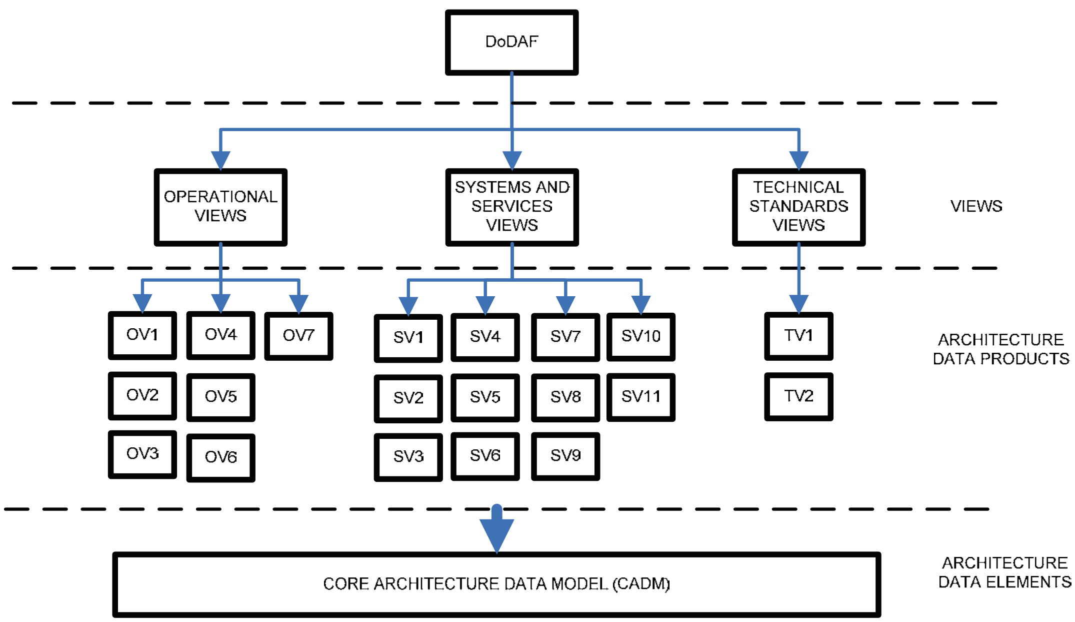

Figure 2: DoD Architecture Framework Version 1.5

It is important to realize that DoDAF is an *integrated* architecture. As such, architecture data elements defined in one product are the same as architecture data elements in another product. In other words, DoDAF has integrated common points of reference linking together architecture data elements thereby ensuring relationships between the architecture data products as well as linkages between the views (i.e., operational, systems/services, and technical standards).

2.3.2 DoDAF Views

In the current instantiation of DoDAF, there are three major perspectives (or views) that are integrated in order to articulate a given architecture:

1. **Operational View (OV).** The OV is a description of the tasks and activities, operational elements, and information exchanges required to accomplish missions. The OV contains graphical and textual products that comprise an identification of the operational nodes and elements, assigned tasks and activities, and information flows required between nodes. It defines the types of information exchanged, the frequency of exchange, which tasks and activities are supported by the information exchanges, and the nature of information exchanges.

2. **Systems and Services View (SV).** The SV is a set of graphical and textual products that describes systems, services, and interconnections providing for, or supporting, operational activities. The SV associates systems resources to the OV. These systems resources support the operational activities and facilitate the exchange of information among operational nodes.

3. **Technical Standards View (TV).** The TV is the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements. Its purpose is to ensure that a system satisfies a specified set of operational requirements. The TV provides the technical system's implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed. The TV includes a collection of the technical standards, implementation conventions, standards options, rules, and criteria organized into profile(s) that govern systems and system elements for a given architecture.

Each of the three views depicts certain architecture attributes. Some attributes bridge two views and provide integrity, coherence, and consistency to architecture descriptions.

2.3.3 Architecture Data Products

Architecture data products are graphical, textual, and tabular items that are developed in the course of building a given architecture description and describe characteristics pertinent to the purpose of the architecture. It is important to distinguish between an architecture view and an architecture product. As stated earlier, a view represents a perspective on a given architecture, while a product is a specific representation of a particular aspect of that perspective. Thus, a view will consist of one or more architecture data products.

2.3.4 Architecture Data Elements

At the lowest level of DoDAF, the architecture data elements are basic building blocks for inclusion in each architecture data product. DoDAF employs a Core Architecture Data Model

(CADM) that defines the standard for architecture data elements as entities and defines their relationships.

2.4 Extensions to DoDAF

While the HV development activity has centred on analogous representations of the DoDAF 'views', the much broader context of architecture frameworks in general was also considered. Specifically, MoDAF and DNDAF have created a series of extensions to DoDAF.

2.4.1 MoD Architecture Framework

While MoDAF has been modeled closely on DoDAF, it has significant points of extension, most notably "Strategic Views". Figure 3 depicts the MoDAF Viewpoints highlighting the nature and role of Strategic Views – the value of aligning HVs within the context of Strategic Views is evident in that human aspects of a capability are envisioned to represent the most significant cost driver and may well possess the longest strategic influencer in terms of time.

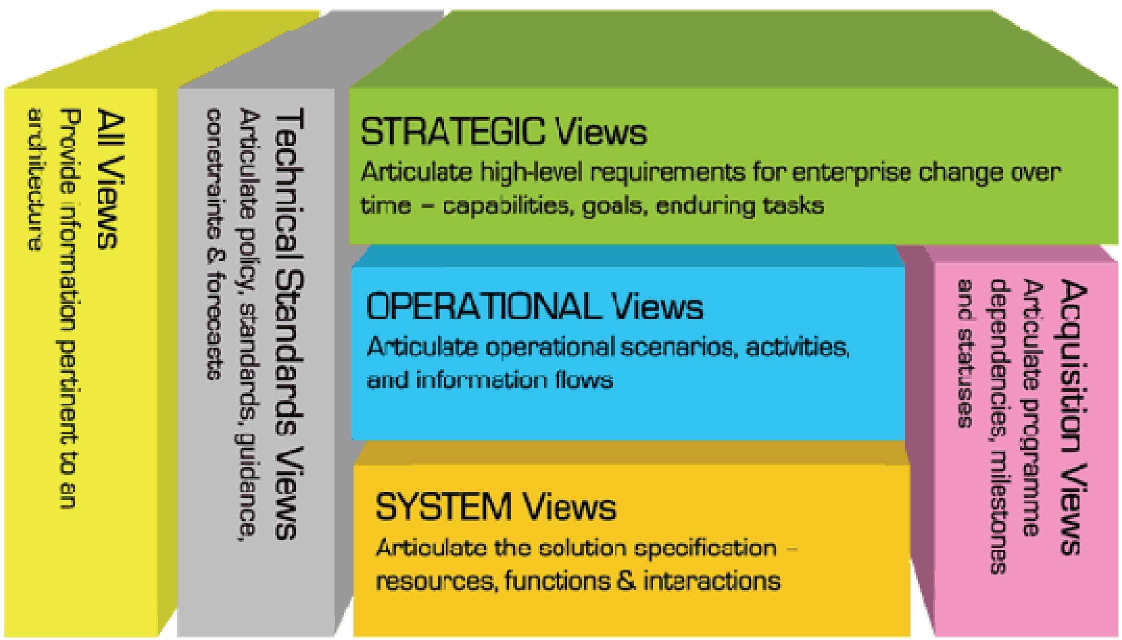

Figure 3: MoDAF Viewpoints[4] (MoD, 2008)

[4] The MoDAF Operational, System, and Technical Standards Views were developed to be consistent with DoDAF and thereby facilitate interoperability.

2.4.2 DND Architecture Framework

DNDAF is largely based on DoDAF 1.0 with adjustments to address specific Canadian DND/CF requirements. In addition, DNDAF makes further use of sound architecture concepts and research to solidify understanding of the DND/CF enterprise while at the same time closing known gaps such as security. As depicted in Figure 4, DNDAF uses the following six views to represent information about the enterprise: Common View (CV), Operational View, System View, Technical Standard View, Information View (IV), and Security View (SecV). The underlying architecture data elements are integrated within the DND Architecture Data Model (DADM).

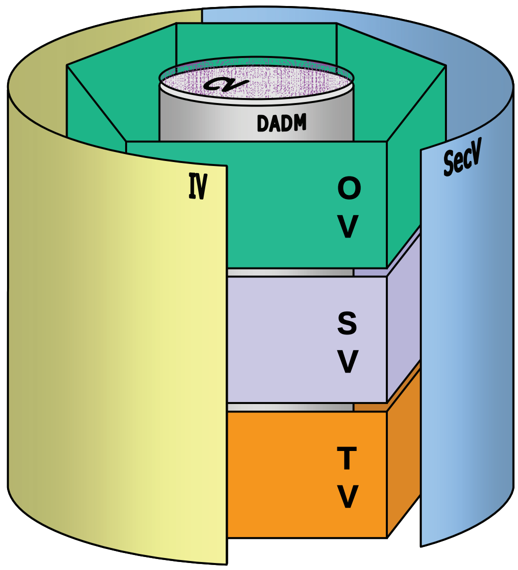

Figure 4: DNDAF Views (DEA, 2007)

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3 Human Views Architecture Products

3.1 General

The importance of considering the people component related to a capability has been recognized in CF doctrine. Specifically, it has been reflected in the National Defence Strategic Capability Investment Plan (DFPPC, 2003a) with the following statement:

> "It is not possible to seriously advance the notion of transformation without addressing human resource issues. … One significant innovation that will occur in the area of Human Resources (HR) long range planning is the introduction of a Human Systems Integration program for DND. This idea has been ongoing since 1998, with development of a process and tools to systematically integrate the domains of human factors engineering, training, personnel, health hazard assessment, and system safety in the defence acquisition cycle. Systematic application of Human Systems Integration ensures that human factors, personnel requirements, trade structure, and training requirements impacts are systematically considered during technology investigation work, concept development and experimentation, project option analysis work, project definition work and project implementation planning."

To date, an attempt has been made within DoDAF to represent humans through "human supplements" within the systems. These are intended to support architecture development across the spectrum of HSI issues. Within Canada, HSI is a strategy to integrate the domains of Human Factors Engineering, Training, Manpower/Personnel, Health Hazards and System Safety (Figure 5). These domains collectively define how the human component will impact system or capability performance (e.g., mission performance, safety, supportability and cost). Conversely, the HSI domains also define how the system impacts the human component (e.g., trade structures, skill gaps and training requirements, manning levels, career progression, selection and retention, workload and morale).

Figure 5: Human Systems Integration Domain

Collectively, the proposed DoDAF human supplements seem insufficient to adequately define, develop, and execute an overall capability program at the S-of-S level in supporting the full breadth of HSI. As a response to this deficiency, a series of HV architecture products are being proposed. Human Views, in the context of this work, are defined as follows:

> Human Views are a set of graphical and textual products that clearly document the human role within a system or capability. As such, they illustrate the role of humans and impacts on the HSI domains (HFE, Manpower/Personnel, Training, System Safety, Health Hazards) of any given architecture design. The HVs enable the measurement of the impacts of alternative architecture designs on roles of humans.

The HV architecture products are intended to facilitate the linkage and transfer of pertinent information between a CE team of systems engineers and architects that are developing investment options at the capability level, and the strategic analysts resident within the HR domain who are responsible for assessing and predicting implications of future HR requirements and capacities. Given the complexity inherent in various S-of-S relationships, the current lack of well defined and universally accepted HVs that are clearly linked to the existing DoDAF OVs and SVs will limit the ability to address key personnel issues at the capability level.

The HV architecture products contained in this report have been designed to target a subset of the overall HSI framework, specifically issues related to Manpower, Career Progression, and Training. The following HV architecture products have been proposed:

1. Manpower Projections (HV-1);

2. Career Progression Roadmap (HV-2);

3. Individual Training Roadmap (HV-3); and

4. Establishment Inventory (HV-4).

The four aforementioned HVs are built on a foundation of competencies (e.g., knowledge, skills, abilities [KSA]) which in turn provide the integration among the architecture data products. Specifically, training is based on increasing competencies among military personnel; recruitment involves identifying and filling in the necessary competency gaps; career progression is based on advancing individuals with the competencies to satisfy job requirements; and inventories demonstrate the current competencies.

The following sections describe each of the HV architecture products including a definition, purpose, detailed description, contribution, as well as the data elements that comprise the product. With respect to the definition of data elements for each HV architecture product, the following categories were mirrored from DoDAF Volume II (DoD, 2007b):

1. Graphical Box Types – expressed by icons shown in the product graphic;

2. Graphical Arrow Types – expressed by lines shown in the product graphic;

3. Non-Graphical Types – expressed by textual labels or implied elements not explicit in the product graphic; and

4. Referenced Type – defined in other products and related to the architecture data elements in the current product.

3.2 Manpower Projections (HV-1)

3.2.1 Product Description

3.2.1.1 Product Definition

The Manpower Projections (HV-1) illustrate the predicted manpower requirements for supporting present and future projects (and programs) that incrementally contribute to the larger CF capabilities. As such, HV-1 provides an aggregated view across projects. This architecture product supports forecasting at the capability level similar to the UK's MoDAF strategic view extensions to DoDAF which include Capability Phasing (StV-3) and Capability to Systems Deployment Mapping (StV-5) (MoD, 2008).[5]

The HV-1 architecture product will be coupled with the Establishment Inventory (HV-4) as well as leverage information from the Systems Evolution Description (SV-8) and Systems Technology Forecast (SV-9) views. Within MoDAF the Strategic View 3 (StV3 – Capability Phasing) provided a model to which HV-1 relates. The StV-3 depicts Capability Phasing and hence provides temporal aspects to fielding capability and illustrates cross-system (in which a system should be seen to include personnel) relationships. There was an expectation that the HV-1 would provide the overarching personnel impact assessment domain when viewed in conjunction with the kind of information provided in the intent of the StV-3. This particular development approach is rooted in the desire to ensure that the people component of a capability is sufficiently elevated in terms of decision-making, as there was a general consensus during the interactions associated with HV development that the human component of a capability was the most 'costly' and had the greatest long term impact and requirement to execute strategically.

3.2.1.2 Product Purpose

The HV-1 architecture product is intended to understand manpower requirement forecasting that will facilitate initial adjustments in training, recruiting, professional development, assignment and personnel management to be conducted. In accordance with the HR checklist developed by CMP (CMP, 2005), the vision for HV-1 would be to allow decision makers to anticipate changes from the capability (or strategic) level down to the project (or tactical) level related to:

[5] While the objective of the project is to extend DoDAF, the requirement to support the decision making capability at the strategic level is best leveraged via the MoDAF strategic views. As such, the analyst will be required to gather information of this nature to support generation of the HV-1.

1. number(s) of personnel;

2. personnel mix;

3. Military Occupational Structure Identifications (MOSIDs) to be impacted;

4. Rank/level distribution/changes;

5. Timeframe when change(s) will be required; and

6. Postings/relocation(s) of personnel.

To that end, the CF will be able to conduct manpower planning to ensure that an appropriate number and mix of personnel with the necessary competencies (e.g., KSA) are potentially available to operate, maintain, and sustain future projects and programs as they are fielded. In addition, addressing manpower affordability early in the acquisition process helps to minimize costs related to system support and ensure that programs do not exceed the CF capacity. As such, the CF can increase the agility and flexibility of the Military Occupational Structure (MOS) and the military work force to adapt to a rapidly evolving and unpredictable world.

3.2.1.3 Product Detailed Description

Over the past couple of decades, the CF has transitioned away from threat-based planning to a strategic capability-based approach for planning. Within the CF, capability definition and planning has been guided by interrelated documents, most notably the:

1. Defence Policy Statement (ADM(Pol), 2005) guides the Canadian Forces in their operations, and assists the DND in the development of a sustainable long-term program;

2. Strategic Capability Planning (SCP) for the Canadian Forces (DPM, 2000) describes a new, capability-based, long-range force development process for the DND/CF; and

3. Strategic Capability Investment Plan (SCIP) (DFPPC, 2003a) sets out the departmental high-level plan for investment in defence capabilities for the next 15 years.

Existing CF capabilities are currently being redefined as Command, Act, Shield, Protect, and Generate in accordance with the CapDEM TDP.[6] High level capabilities have been successively decomposed to yield an inventory of functions in a nested order such that a hierarchy is captured. For instance, the Command capability has been further decomposed into the following first-level functions:

1. Orient – Achieve Situational Awareness;

[6] The SCP [10] defines capabilities as Command, Information & Intelligence, Conduct Operations, Mobility, Protect Own Forces, Sustain, Generate Forces, Coordinate with OGIs. Similarly, the SCIP [11] defines capability thrusts as Command & Sense; Support, Sustainment & Mobility; Force Generation and Corporate; Effective Engagement.

2. Evaluate – Provide Options and Advice;

3. Decide – Provide Choice Authorization;

4. Ensure Execution;

5. Communicate – Share Information; and

6. Processing.

This decomposition of CF capabilities is representative of MoDAF's Capability Taxonomy (StV-2) architecture product. It is informative to view MoDAF in this context as DoDAF does not formally provide a view that explicitly represents capability areas.

Management of capabilities within the CF can be viewed as being comprised of two interdependent hierarchies: new system acquisition and existing system management (Figure 6).

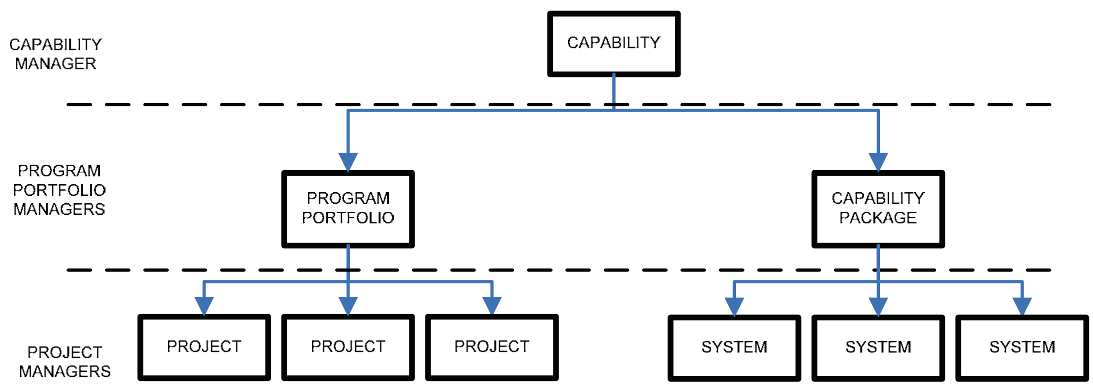

Figure 6: CF Capability Hierarchy

The acquisition of new systems (left side of Figure 6) is managed through a series of program portfolios comprised of projects and initiatives. As such, the lower level projects and initiatives can be mapped directly to higher level capability thrusts.[7] Each level of the capability hierarchy is governed by one or more managers with a different scope. For instance, the project manager will forecast the necessary requirements to support Initial Operating Capability (IOC) and Final Operating Capability (FOC) for their individual project. In turn, a program portfolio manager will assess the amalgamated requirements that are collectively imposed by the projects. Existing systems that are presently fielded and operational (right side of Figure 6) can be amalgamated into capability packages. The management of these existing capability packages is performed by the operational community.

[7] The SCIP has mapped equipment acquisition projects to defence capabilities.

The HV-1 architecture product (Figure 7) maintains the hierarchy by mapping current and planned projects to each CF capability. Specifically, the left side of the HV-1 lists all projects grouped by program portfolios as well as all systems grouped by capability packages. Planned (or future) projects are differentiated by those that do and do not possess Government expenditure approval (green vs. red). Individual projects are mapped to one or more capabilities with varying levels of contribution. For instance, System 1 in Capability Package A contributes to both the Command and Shield capabilities as denoted by the coloured circles in the associated cells. The different colours are used to illustrate the different levels of contribution of a project or system to a given capability. The HV-1 architecture product can be filtered to include only those projects and systems applicable to a single capability.

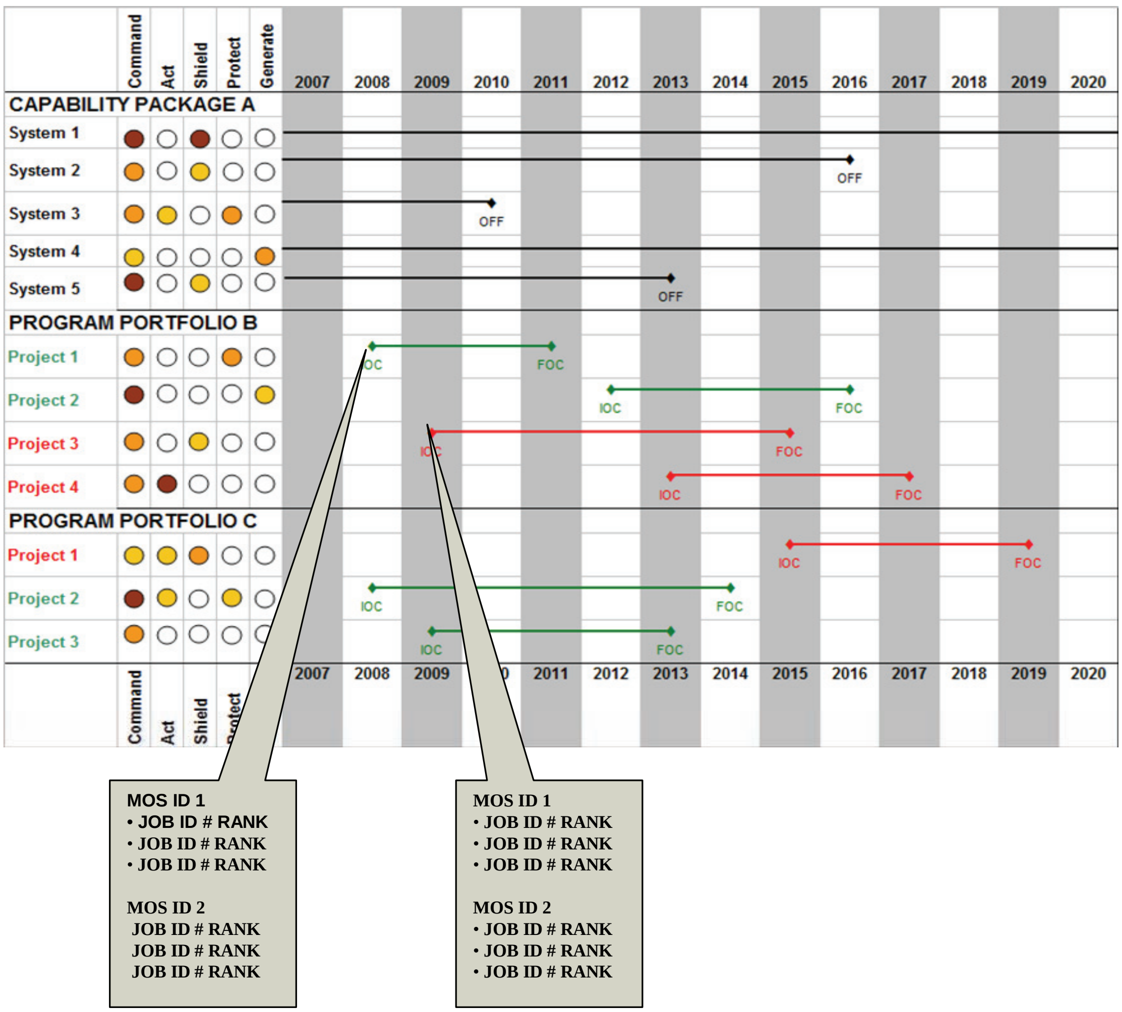

Figure 7: Manpower Projections (HV-1)

For each year, the manpower requirements for individual projects and systems (current and planned) are available and grouped by MOSID, job, and rank. For existing systems, the manpower values represent the number of individuals operating, maintaining, and sustaining the system. Similarly, the manpower values for a future project represent the projected number of individuals required to field the new system. As such, the individual project and system manpower requirements can be aggregated across program portfolios and capability packages or even the larger capabilities for a given year. At the highest or capability level, the total number of military personnel for each year reflects the preferred manning levels for the CF.

3.2.1.4 Product Contribution

By maintaining the CF capability hierarchy, insights into manpower requirements are available at all levels.

1. Project managers can understand future manpower needs to support both milestone decision reviews as well as mission and performance objectives (e.g., IOC, FOC). As such, training and recruitment strategies can be developed and implemented at the tactical level to ensure the necessary personnel are trained to support IOC and FOC. The most efficient and cost-effective manpower mix (military, civilian) can also be realized to best support the project;

2. Program portfolio managers can set appropriate manpower goals and parameters as an accumulation of manpower demands across the current and future projects. In turn, manpower trade-offs between projects can be assessed in order to address any investment constraints related to the larger program portfolio; and

3. Capability managers can conduct strategic planning of manpower resources including long-range strategies and workforce forecasts across a given capability. In addition, HV-1 provides complete transparency that allows decision makers to view the ‘ripple effect’ caused by any manpower adjustments to individual projects or systems.

3.2.2 Product Data Element Definition

Table 1 provides an overview of the architecture data elements for the Manpower Projections (HV-1) architecture product.

Table 1: Data Element Definitions for Manpower Projections (HV-1).

Data Elements	Attributes	Example Values/Explanations
Graphical Box Types		
Project	Name	Name/identifier for the project.
	Description	Textual description of the project.
	Capability Contribution	Level of contribution for the project with respect to a capability.
	IOC Date	Date of Initial Operating Capability.
	FOC Date	Date of Final Operating Capability.

Non-Graphical Box Types		
Capability	Name	Name/identifier for the capability.
	Description	Textual description of the capability.
Program Portfolio	Name	Name/identifier for the program portfolio.
	Description	Textual description of the program portfolio.
Capability Package	Name	Name/identifier for the capability package.
	Description	Textual description of the capability package.
Referenced Types		
Inventory		See HV-4 Definition Table.
System		See SV-9 Definition Table.
MOSID		See HV-2 Definition Table.
Job		See HV-2 Definition Table.

3.3 Career Progression Roadmap (HV-2)

3.3.1 Product Description

3.3.1.1 Product Definition

The Career Progression Roadmap (HV-2) illustrates career progression within a particular CF MOSID as well as the essential tasks, knowledge, skills, and abilities (and proficiency level) required for a given job. The Career Progression Roadmap is tightly coupled with the Individual Training Roadmap (HV-3) as well as the Organizational Relationship Chart (OV-4).

3.3.1.2 Product Purpose

The HV-2 architecture product can be used to:

1. Address impacts of alternative systems and capability designs on career progression;

2. Determine jobs available given an individual's current job and occupation;

3. Assess the competencies required for each individual job; and

4. Support personnel planning by identifying the availability of individuals with the necessary competencies early in the acquisition process.

3.3.1.3 Product Detailed Description

The Military Occupational Structure forms the foundation of the CF HR management system whereby it impacts HR activities including personnel production planning, recruiting, professional development, assignment and personnel management. The MOSART project aims to modernize the MOS by managing the work through "jobs" rather than positions. Jobs are defined as "similar work grouped on the basis of tasks, knowledge, skills, and abilities performed by personnel in individual positions". Career fields will be built using an optimum combination of jobs, occupations and sub-occupations based on the principles of MOS design. The rationale is to increase the agility and flexibility of the MOS and the military work force to adapt to a rapidly evolving and unpredictable world.

Figure 8 illustrates the CF MOS hierarchy whereby career fields are composed of occupations (and sub-occupations). An occupation represents a grouping of related jobs that exhibit a common set of duties and tasks which in turn require similar qualifications. For instance, the Combat Arms career field is comprised of the Infantry, Armoured, and Artillery occupations. An occupation is further subdivided into job groupings which are differentiated according to a MOSID. The Artillery occupation has three MOSIDs: 00179 (officers), 00009 (air defence [AD] non-commissioned member [NCM]), and 00008 (field [FD] artillery NCM).

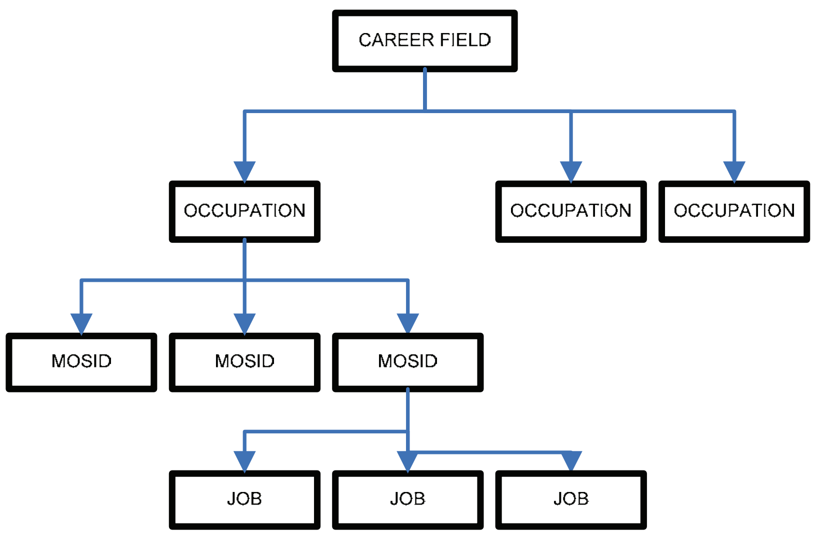

Figure 8: CF Military Occupational Structure

For each MOSID, career advancement follows a pre-defined progression of jobs with accompanying ranks as represented by the Career Progression Roadmap (HV-2) architecture data product (Figure 9). Typically, this involves recruiting military personnel into the lower ranks as an NCM (private) or an officer such as a 2nd lieutenant or Officer Cadet (OCdt). During their career, individuals will incrementally increase in rank whereby the expertise required at higher ranks is highly dependent on the experience and training received at the lower ranks. HV-2 depicts the entry level job for a MOSID and subsequent advancement opportunities. The configuration of the HV-2 will vary between Regular Force (Reg F), Primary Reserve (P Res), and Special Force (Spec F).

In accordance with Canadian Forces Individual Training & Education System (CFITES) (CMP, 2006), specifications describe job performance for all CF occupations and include:

1. General Specifications (GS) describe the duties, tasks, knowledge, skills, and abilities that are common to and required by all military personnel. In addition, these specifications identify Environmental Requirements that are unique to each of the environmental elements (i.e. sea, land, air);

2. Occupational Specifications (OS) describe the specific requirements for each military occupation; and

3. Occupational Specialty Specifications (OSS) describe a unique set of tasks, knowledge, skills, and abilities required to perform a specific job. Not all personnel in the occupation will be trained in these areas.

In some occupations, individuals will have the opportunity to choose between specialties which may have their own sub-element advancement progression. For example, the HV-2 for the Armoured occupation illustrates a separate career path for the Reconnaissance (Recce) specialty versus the Tank specialty. In the HV-2, these career paths are differentiated by symbology whereby the squares represent those jobs within a typical career path (i.e., GS and OS) and diamonds represent those jobs within a speciality path (i.e., OSS). The lines between the jobs represent the career progression opportunities among jobs. Specifically, a solid line represents the base career stream whereas a dashed line signifies the speciality stream. Shaded squares represent jobs that are common across MOSIDs within an occupation (i.e., not differentiated by OSS).

To advance among the jobs, individuals must complete a Development Period (DP). A DP is a timeframe in a career during which an individual receives the required training, employment, and/or opportunity to develop the specific competencies to advance. As an individual advances among the DPs, (s)he is provided a progressive increase in the levels of responsibility, authority, leadership ability, and other related competencies. This, in turn, results in a progressive increase in rank. In general, the degree to which competencies relate directly to job performance decreases with increasing rank as more senior positions focus on leadership potential and ability. Details regarding the training requirements mapped to each DP within a given MOSID are provided in the Individual Training Roadmap (HV-3) architecture product.

Each individual job is defined by a series of attributes called Job Performance Requirements (or Occupational Performance Requirements). For each individual MOSID, these requirements are currently housed in the CF Manuals of Military Occupational Structure and are going through a restructuring by the Director Personnel Generation Requirements (DPGR). Table 2 summarizes the job attributes in relation to the HV-2 architecture data product.

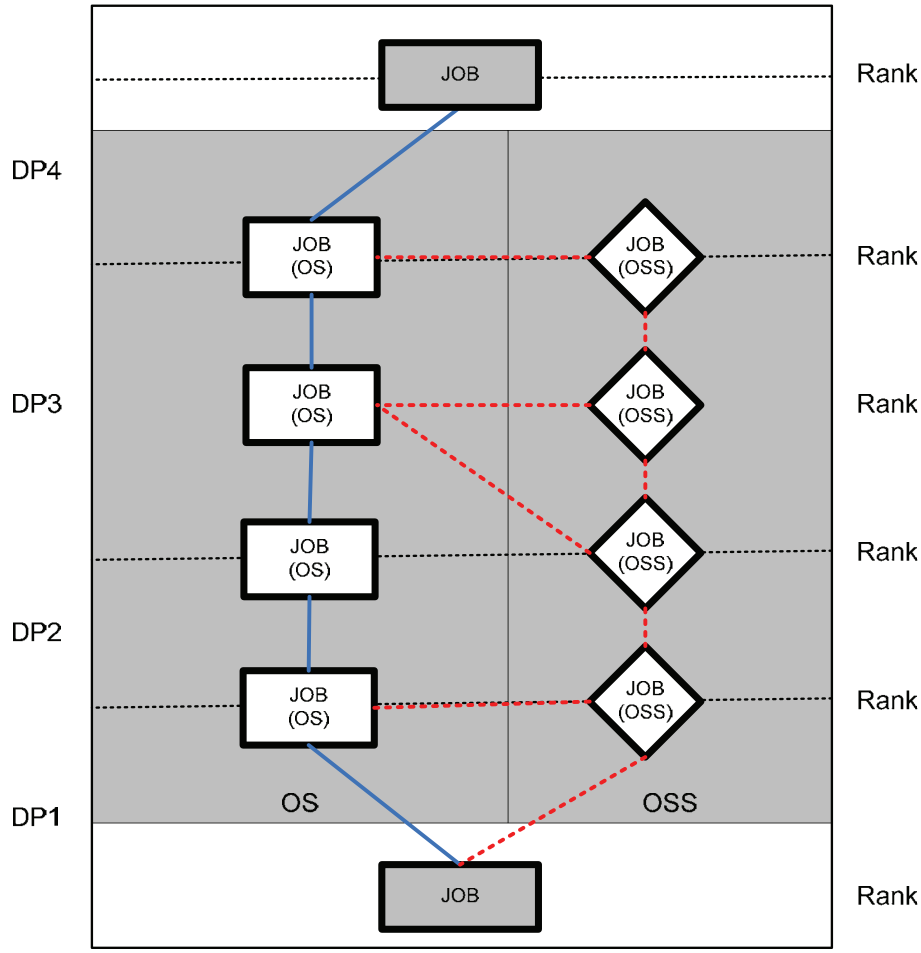

Figure 9: Career Progression Roadmap (HV-2)

At the lower ranks for both NCMs and officers, career progression is constrained by the occupation. This is directly attributable to the specialized competencies that are acquired at the early stages of an individual's military career. As such, career transitions across occupations are not easily supported within the current MOS. However, at a certain point in the career progression structure, jobs within different occupations will converge. For instance, the Artillery and Armoured occupations do not exhibit cross-over at the lower jobs (and ranks); however, a Regimental Sergeant Major (RSM) (and subsequently, a Chief Warrant Officer [CWO]) could be staffed by an individual from either occupation.

3.3.1.4 Product Contribution

From a project management perspective, understanding the existing career progression for different MOSIDs allows project managers to assess the impact of and determine solutions accommodating new jobs resulting from system acquisitions or modifications. Typically, a Target Audience Description (TAD) is created to articulate the necessary competencies that are expected of personnel in order to operate, maintain, and support the new system. A gap analysis can then be conducted to compare the competencies required by new jobs and the competencies associated with the existing database of CF jobs.

The project manager can also utilize the HV-2 architecture data product to consider the impact to promotions and career progression when establishing the project costs. In turn, these costs should be considered during trade-off analyses between potential solutions.

HV-2 provides individuals with visibility into the opportunities for career progression. In addition, Competency Based Management (Arsenault & Thompson, n.d.) can be facilitated whereby career paths are managed by ensuring that individuals selected for career advancement possess the necessary competencies to perform their next job. This is in contrast to existing career advancement and promotion strategies involving the selection of the 'best' performer within a given occupation. This does not guarantee that the individual possesses the necessary competencies to complete the requirements imposed by the next job.

3.3.2 Product Data Element Definition

Table 2 provides an overview of the architecture data elements for the Career Progression Roadmap (HV-2) architecture product. The 'job' attributes have been extracted from the Job Description Structure created as part of MOSART. The HV-2 will provide decision makers with a common information set from which career path implications and anticipated strategic personnel requirements can be assessed.

Table 2: Data Element Definitions for Career Progression Roadmap (HV-2).

Data Elements	Attributes	Example Values/Explanations
Graphical Box Types		
Job	Title	Title of the job (e.g., Armoured Fighting Vehicle Commander, Armoured Reconnaissance Surveillance Operator).
	Code/Identifier	Unique Code/identifier of the job.
	Rank	Minimum military rank requirement for holding the job.
	Type	Type of job – predominantly non-office environment; predominantly office environment; combination of office and non-office.
	Establishment Positions	See OV-4 Definition Table.
	Environment	Environment in which the job is performed – Land, Sea, Air or CF.
	Security Clearance	Minimal security clearance required to perform the job.
	Primary National Occupational Classification (NOC)	Primary NOC code for the job.

<table>
<tr><td></td><td>Secondary NOC</td><td>It is also possible to link the job to a Secondary NOC. This is optional and may not be applicable.</td></tr>
<tr><td></td><td>Functional Description</td><td>A brief description of the scope of the job and the level of expertise required.</td></tr>
<tr><td colspan="3">Graphical Arrow Types</td></tr>
<tr><td>Promotion</td><td>Label</td><td>Identifier for promotion.</td></tr>
<tr><td></td><td>Description</td><td>Textual description of transition.</td></tr>
<tr><td></td><td>Type</td><td>Relates to the career path (Occupational, Specialty).</td></tr>
<tr><td colspan="3">Non-Graphical Types</td></tr>
<tr><td>MOS</td><td>Career Field</td><td>List of career field(s) applicable to the job.</td></tr>
<tr><td></td><td>Occupation</td><td>List of occupation(s) applicable to the job.</td></tr>
<tr><td></td><td>Sub-occupation</td><td>List of sub-occupation(s) applicable to the job.</td></tr>
<tr><td></td><td>Component</td><td>List of all component(s) applicable to the job.</td></tr>
<tr><td></td><td>Element</td><td>List of all element(s) applicable to the job.</td></tr>
<tr><td>Responsibility</td><td>Services</td><td>List of services that are provided; and to whom those services are provided (sub-unit level, unit level, sub-formation level, formation level, national level, international level).</td></tr>
<tr><td></td><td>Personnel</td><td>Includes:
• Responsibilities for the physical and mental welfare of personnel including the safety to others, the impact on CF provided direct support and family support resources.
• Development of personnel and career management.
• Discipline and evaluation of personnel and the operational responsibility for personnel with potential consequences (i.e., number of sub-units and units controlled and the total number of personnel).</td></tr>
<tr><td></td><td>Resources</td><td>Includes:
• Assets being commanded, controlled, operated, inspected, serviced or repaired.
• Assets required to provide the service (sub-units, units, tools, test equipment, etc.).
• Stores, documents or monies being controlled, expended or safeguarded.</td></tr>
<tr><td></td><td>Legal and Regulatory Compliance</td><td>Includes accountability for enforcing legislation or regulations, for ensuring third-party mediation, conciliation or arbitration, and for ensuring compliance by others with standards, guidelines and practices.</td></tr>
<tr><td></td><td>Consequence of error</td><td>Consequences of errors at all levels (sub-unit, unit,</td></tr>
</table>

		sub-formation, formation, national, international).
Competency	Certifications	Minimum certifications level that is required to perform the job adequately.
	Qualifications	Minimum qualifications level that is required to perform the job adequately.
	Abilities & Aptitudes	Minimum abilities and aptitudes that are required to perform the job adequately.
Effort	Physical	Describes the physical effort requirement of the job not the person.
	Mental	Describes the mental effort requirement of the job not the person.
Working Conditions	Work Environment	Lists the exposure to disagreeable psychological and physical work environment in either Sea, Air, and/or Land environment(s) such as the exposure and time of exposure to extremes of heat, cold, obnoxious odours, noise, wet, dust/dirt, weather, bio-hazards, chemicals, etc.
	Risk to Health	List of risks to health inherent in the work despite safety precautions taken, such as wearing protective clothing.
Job Performance Requirements	Duty Areas	List of all duty areas.
	Task Statements	List of all task statements required to perform the job and the level of proficiency.
	Knowledge Statements	List of all knowledge statements required to perform the job and the level of proficiency.
	Skill Statements	List of all skill statements required to perform the job and the level of proficiency.
	Attitude Statements	List of all attitude statements required to perform the job and the level of proficiency.
Referenced Types		
Position		See OV-4 Definition Table.
Development Period		See HV-3 Definition Table.

3.3.3 Example

Figure 10 illustrates the notional Armoured Occupation (MOSID 00005) career progression for a Reg F soldier (i.e., NCM) within the regimental system. In this example, all soldiers occupy a common entry level job, Armoured Crewman, with a rank of Private (Pte). Upon completing DP1, the Armoured Crewman has taken one of two career streams: Armoured Recce (OS career stream) or Armoured Direct Fire (DF) (OSS career stream). As the soldier continues to advance through the jobs, an associated increase in rank is obtained. Upon completion of DP4 for MOSID 00005, the soldier can occupy the job of Armoured Squadron Sergeant Major (SSM) and subsequently Regiment Sergeant Major (RSM). Similar to the entry level job of Armoured

Crewman, the Armoured SSM job is common regardless of the lower career stream taken by the soldier (i.e., Recce vs. DF).

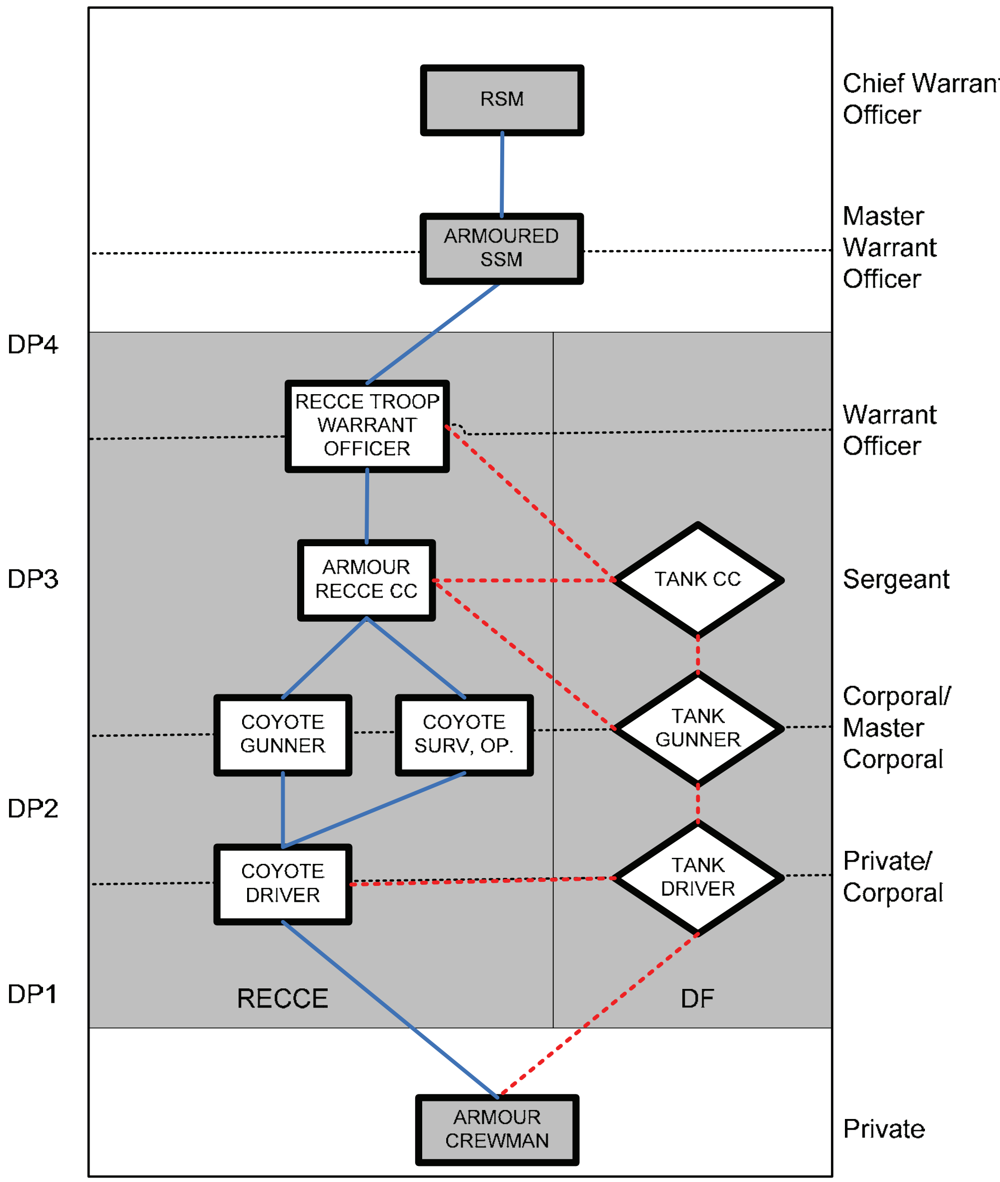

Figure 10: Armoured Crewman (MOSID 00005) Career Progression Roadmap (HV-2)

3.4 Individual Training Roadmap (HV-3)

3.4.1 Product Description

3.4.1.1 Product Definition

The Individual Training Roadmap (HV-3) architecture product illustrates the instruction or education, and on-the-job or unit training required to provide personnel their essential tasks, KSA to meet the job requirements. The training progression is unique to a particular CF MOSID (e.g., Armoured Non-Commissioned Officer, MOSID 00008). The Individual Training Roadmap is tightly coupled with the Career Progression Roadmap (HV-2) due to the interdependencies between training and career progression.

3.4.1.2 Product Purpose

The HV-3 architecture product can be used to:

1. Address impacts of alternative system and capability designs on training requirements and curriculae; and

2. Plan training programs to support the acquisition of the necessary KSA to allow military personnel to advance within a given career field.

3.4.1.3 Product Detailed Description

Within the CF, training and education for individuals are regulated in accordance with the management model known as the CFITES which helps to:

1. Identify if what an individual learns meets the requirements of the tasks and duties;

2. Define performance objectives and document them in a qualification standard;

3. Determine a learning programme and an environment which enables an individual to achieve the performance objectives; and

4. Identify individuals, or numbers of personnel, who require qualifications.

In turn, CFITES supports the operational capability of the CF by ensuring its members possess the necessary competencies through training and education to perform effectively.

The Individual Training Roadmap (HV-3) architecture product illustrates the training and education requirements within each DP in order to support the career advancement within a given MOSID. To that end, a training block ensures an individual has the necessary competencies to meet the requirements of a job. The HV-3 symbology is similar to the HV-2 architecture data product. Specifically, squares represent the training units for the OS career stream whereas the diamonds represent the training units for the OSS career stream.

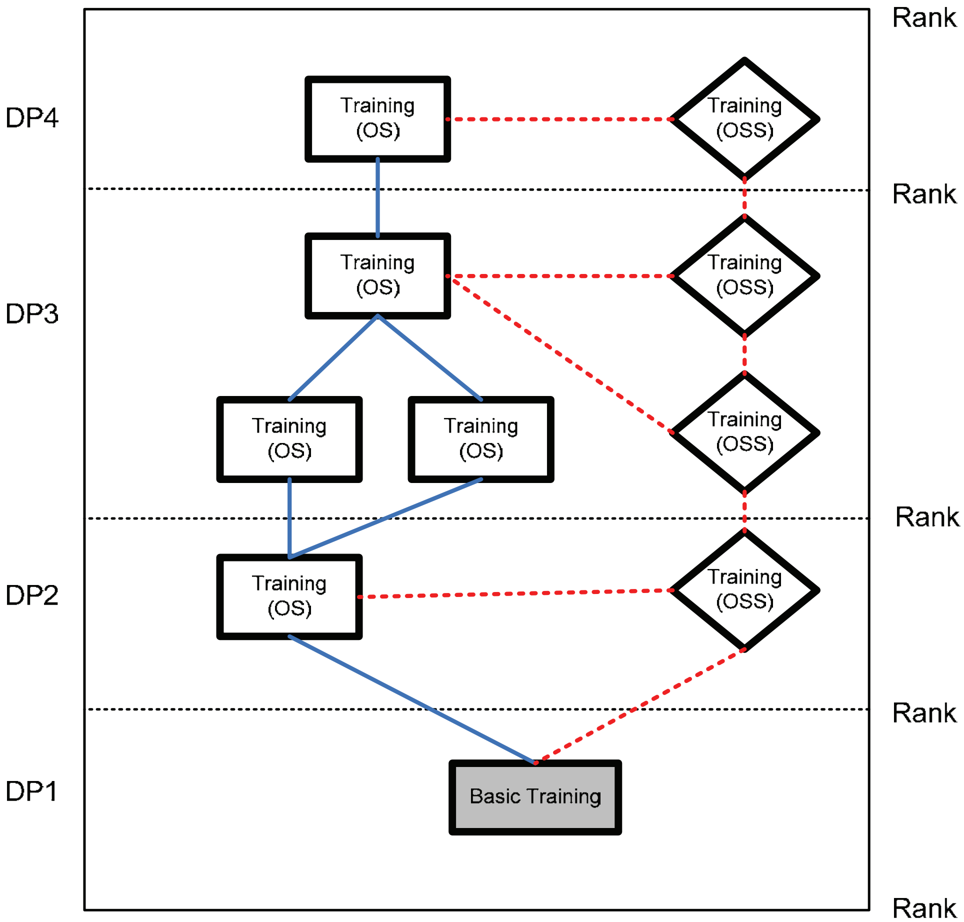

Figure 11: Individual Training Roadmap (HV-3)

3.4.1.4 Product Contribution

In conjunction with utilizing the HV-2 architecture data product to identify the impact of new systems on all aspects related to the personnel domain (e.g., competencies, career progression, promotions, etc.), the HV-3 architecture data product enables the project manager to assess the impacts to the training domain. As a result, costs associated with adjusting existing training programs (i.e., concepts, strategies, and tools) and/or developing new programs for the acquisition of a system can be determined. This cost will also be used to compare competing solutions. Realizing the training solution at an early stage of a materiel acquisition program helps to minimize costs associated with this domain as well as commence the implementation of the training program at the outset.

3.4.2 Product Data Element Definition

Table 3 provides an overview of the architecture data elements for the Individual Training Roadmap (HV-3) architecture product. Sources for training data elements include DAOD 5031-2 (FIN CS, 2006), CFITES documentation (CMP, 2006), and DAOD 5031-8 (FIN CS, 2003). In many respects, the HV-3 and HV-2 represent different lenses through which personnel requirements can be viewed. Career progression is tightly coupled with training requirements and success in achieving training certifications. The HV-3 will undoubtedly show close correlation with KSA at various stages in career development, and it is expected that as rank increases the degree to which KSA will evolve toward leadership-centric competencies will increase.

Table 3: Data Element Definitions for Individual Training Roadmap (HV-3).

Data Elements	Attributes	Example Values/Explanations
Graphical Box Types		
Training Course	Title	Name of the training course.
	Description	Text that describes the training course.
	Category	Relates to HR production and may contain any type of Individual Training and Education (IT&E) that enables CF members to: • Achieve TES in a military occupation and removal from BTL based on applicable IT&E for recruit, basic officer, second language, environment, basic occupational level, and specialty qualification connected to the basic occupational level (Basic). • Perform advanced and specialty duties, which may place them on an advanced training list, based upon the applicable IT&E for advanced occupational levels; specialty qualifications; second and foreign language; leadership; and university degrees (Non-Basic).
	Type	Relates to the operational requirement for IT&E and enables CF members to: • Be functionally operational in a military occupation and progress from an initial qualification level to higher levels in the military occupation (Occupation Training). • Perform the tasks in an occupational specialty specification (Specialty Training). • Meet a departmental objective or goal that may not be based on specifications, but is mandated by the Government of Canada, DND or Level 1s, such as for harassment prevention, health and safety, and office automation (General Purpose Training).
	Sub-type	Relates to specific situations involving IT&E and

<table>
<tr><td></td><td></td><td>enables CF members to:
Learn tasks while performing duties, guided by performance and enabling objectives and checks in a qualification standard that leads to a CF qualification (On the Job Training).
Maintain specific skills, knowledge and attitudes related to a position or a CF qualification (Refresher Training).
Perform the tasks associated with new equipment, systems or directives upon their fielding, delivery or initiation (Initial Cadre Training).
Perform the tasks associated with new equipment, systems or directives in order to replace the initial cadre (Conversion Training).
Succeed other CF members in specific positions due to promotions, postings, attrition and changes to the establishment (Regeneration Training).</td></tr>
<tr><td></td><td>Career Field</td><td>Career field for which the training course is a part of.</td></tr>
<tr><td></td><td>Occupation</td><td>Occupation for which the training course is a part of.</td></tr>
<tr><td></td><td>Sub-occupation</td><td>Sub-occupation for which the training course is a part of.</td></tr>
<tr><td></td><td>Start Time</td><td>Start time of the training course.</td></tr>
<tr><td></td><td>End Time</td><td>End time of the training course.</td></tr>
<tr><td></td><td>Location</td><td>Location at which the training course is offered.</td></tr>
<tr><td></td><td>Cost</td><td>Cost associated with training personnel via the course.</td></tr>
<tr><td colspan="3">Graphical Arrow Types</td></tr>
<tr><td>Stream</td><td>Type</td><td>Represents the type of training stream – Occupational Specification (OS) (or Base Training); Occupational Specialty Training (OSS).</td></tr>
<tr><td colspan="3">Referenced Types</td></tr>
<tr><td>Development Period</td><td></td><td>See HV-2 Definition Table.</td></tr>
<tr><td>Rank</td><td></td><td>See HV-2 Definition Table.</td></tr>
<tr><td>Job</td><td></td><td>See HV-2 Definition Table.</td></tr>
<tr><td>Job Performance Requirements</td><td></td><td>See HV-2 Definition Table.</td></tr>
<tr><td>Position</td><td></td><td>See OV-4 Definition Table.</td></tr>
</table>

3.4.3 Example

Figure 12 illustrates the individual training roadmap to support advancement by a Reg F officer within the Armoured Occupation (MOSID 00178).

At the outset, an officer cadet will attend a Basic Officer Training Course (BOTC) during DP1 at the Canadian Forces Leadership and Recruit School in Saint-Jean-sur-Richelieu, Quebec. During BOTC, officers learn the principles of leadership, regulations and customs of the service, basic weapons handling and first aid. Upon completion of BOTC, the armoured officer will either be trained as an Armoured Recce Officer (OS) or a Tank Crew Commander (OSS).

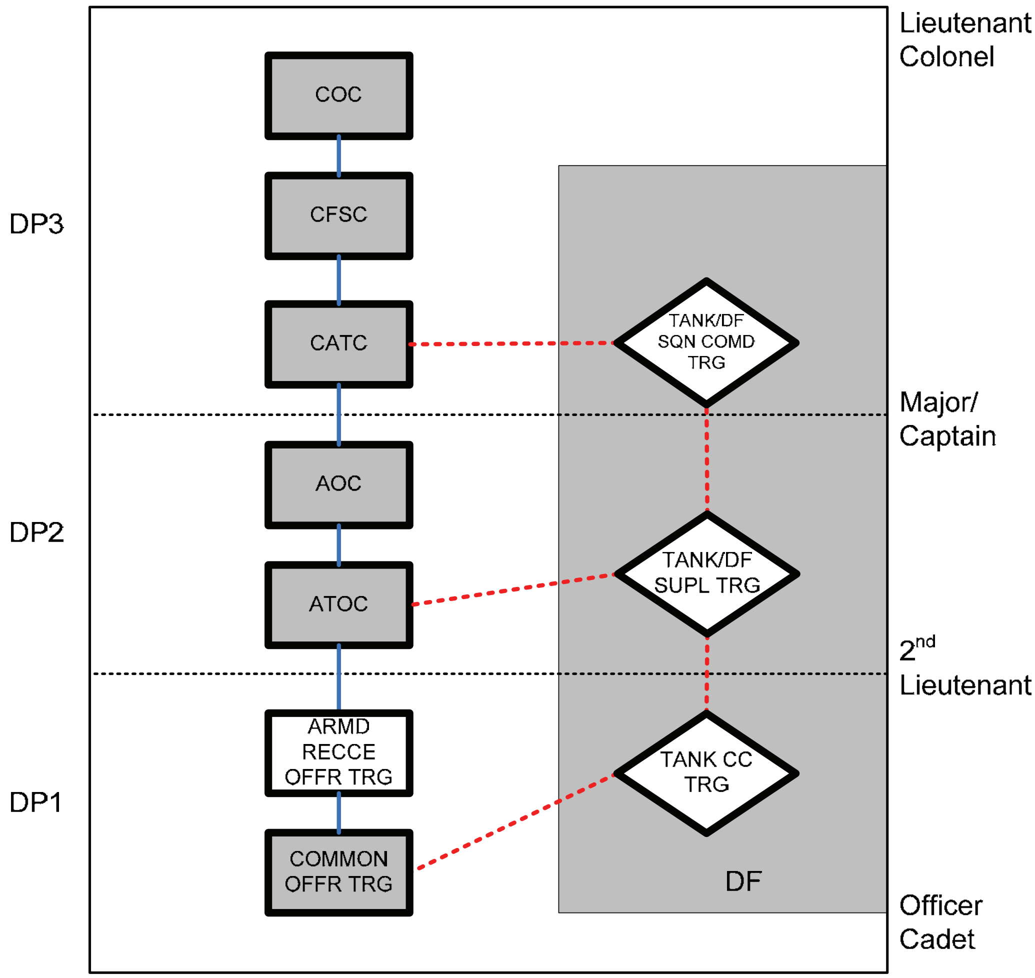

Figure 12: Armoured Officer (MOSID 00178) Individual Training Roadmap (HV-3)

During DP2, all officers are instructed on tactics through the Army Tactics and Operations Course (ATOC) whereby officers gain an understanding and ability to plan and conduct operations at the Combat Team level. Upon completion of ATOC, the Army Operations Course (AOC) prepares all junior officers to act as staff in a tactical headquarters at the unit and formation level within the contemporary operating environment, throughout the full spectrum of operations. Speciality training is also provided for officers selected to command tank/direct-fire troops.

Within DP3, officers continue to be trained on the applicable common, environmental, and occupational qualifications. This includes the Combined Arms Team Commander (CATC), Canadian Forces Staff College (CFSC) and Commanding Officers Course (COC).

3.5 Establishment Inventory (HV-4)

3.5.1 Product Description

3.5.1.1 Product Definition

The Establishment Inventory (HV-4) architecture product defines the current number of military personnel by rank and job within each CF establishment[8]. HV-4 can be used in conjunction with forecasting results presented in the Manpower Projections (HV-1) architecture product to assist decision makers in dealing with manpower requirements definition and to readily identify anticipated ‘gaps’ in personnel. The direct relationship between existing manpower levels and proposed programs may be addressed through closer examination of the HV-2 and HV-3 products as trade-offs between existing career paths and anticipated requirements. Alterations to training programs may also address these ‘gaps’.

3.5.1.2 Product Purpose

The HV-4 architecture product can be used to:

1. Support forecasting of the trained effective strength;

2. Assist with determining personnel available to support deployment on operational missions; and

3. Support predicting the number of individuals that must be trained, recruited, etc. to fill gaps beyond the presently defined forecast years (i.e., ‘out years’).

[8] An establishment is a “recapitulation of the authorised positions in an organization” [12]. Military personnel are categorized according to rank, MOSID, and qualification level.

3.5.1.3 Product Detailed Description

Within the CF, the total number of personnel from the CMP perspective is constrained by the Total Paid Strength (TPS) or the total amount of money. The TPS is an aggregation of the military personnel within the following categories (Treasury Board of Canada Secretariat, 2006):

1. Trained Effective Strength (TES) accounts for that component of strength that is functionally operational (CMP, 2006; Treasury Board of Canada Secretariat, 2006);

2. Basic Training List (BTL) accounts for personnel undergoing the basic level of training required to achieve the qualification requirements for first employment in an occupation (CMP, 2006); and

3. Non-Effective Strength (NES) accounts for that component of strength that is not functionally operational (e.g., retirement leave, injured, etc.).

The TPS is a fixed quantity with a cap and is primarily based on a predefined budgetary component conceptually related to predicted mission requirements as defined in the Defence Plan.

To address operational requirements, the number of authorized positions in the CF that require trained personnel, or Trained Effective Establishment (TEE), is determined by the Vice Chief of Staff (VCDS). In an ideal world, the TEE would equal the TES whereby trained individuals occupy each of the authorized positions. In reality, the TES falls short of the TEE due to the inability of the CF to fill each TEE requirement thereby resulting in vacancies. If the TEE demands exceed the TPS and a Government decision is taken to maintain the current TPS, staffing jobs to support a new system acquisition will require displacing personnel from elsewhere within the force structure as opposed to recruiting and training new individuals. HVs will be able to support these trade-offs as they are developed within an integrated architecture approach and therefore changes will ‘ripple’ across the HV products and assist decision makers in considering these types of personnel balances.

For each CF establishment, the HV-4 architecture product provides a breakdown of the number of military personnel by rank for each MOSID and job (Figure 13). For each job, a breakdown of Reg F, P Res, and Spec F is also provided. Training establishments (e.g., Canadian Forces Training Development Centre, Armour School) would provide a breakdown of individuals contributing to the overall BTL pool for the CF. Other establishments (e.g., army units such as Canadian Mechanized Brigade Group) would account for individuals that form part of the TES and NES. In some instances, an establishment may include individuals belonging to all three categories (i.e., TES, BTL, and NES). As such, summing up the inventories across all establishments provides an indication of the Total Paid Strength for the CF.

ESTABLISHMENT				RANK															
				Pte	Cpl	MCpl	Sgt	WO	MWO	CWO	2Lt	Lt	Capt	Maj	Lcol	Col	Reg F	P Res	Sped F
ARMOURED	SOLDIER (00005)		Armoured Crewman	#															
ARMOURED	SOLDIER (00005)	RECCE	Coyote Driver	#	#														
ARMOURED	SOLDIER (00005)	RECCE	Coyote Gunner		#														
ARMOURED	SOLDIER (00005)	RECCE	Coyote Surv Ops																
ARMOURED	SOLDIER (00005)	RECCE	Armed Recce Comd																
ARMOURED	SOLDIER (00005)	DF	Tank Driver	#	#														
ARMOURED	SOLDIER (00005)	DF	Tank Gunner		#														
ARMOURED	SOLDIER (00005)	DF	Tank Loader		#	#													
ARMOURED	SOLDIER (00005)	DF	Tank Commander			#	#	#											
ARMOURED	SOLDIER (00005)		Troop Warrant				#	#											
ARMOURED	SOLDIER (00005)		Squadron SM						#										
ARMOURED	SOLDIER (00005)		Regiment SM							#									
ARMOURED	OFFICER (00178)	RECCE	Armd Recce Officer								#								
ARMOURED	OFFICER (00178)	RECCE	Job 2								#	#							
ARMOURED	OFFICER (00178)	RECCE	Job 3									#							
ARMOURED	OFFICER (00178)	RECCE	Job 4										#						
ARMOURED	OFFICER (00178)	DF	CC/Troop Leader										#						
ARMOURED	OFFICER (00178)	DF	Battle Captain										#						
ARMOURED	OFFICER (00178)	DF	Sqn Commander											#					

Figure 13: Establishment Inventory (HV-4)

3.5.1.4 Product Contribution

Currently, the HV-4 data elements are used by CMP to support the generation of the Projected Status Report (PSR). The PSR is produced bi-annually to assess the number of military personnel that need to be produced to support the forecast requirements. It looks ahead three years. The TES for future years is forecasted by rank based on the impact of factors including attrition, generation, and promotions. Based on a gap analysis between the forecasted TES and projected personnel requirements, solutions (e.g., training, recruitment, attrition, etc.) can be realized and instituted at an earlier stage.

HV-4 details the TES for the current year within the HV-1 architecture product. As such, a comparison between this value and a projected TES allows stakeholders to determine potential solutions to gaps related to areas such as manpower. In turn, analyzing the HV-2 and HV-3 architecture products would allow decision makers to understand the progress of candidate personnel with respect to career progression and training.

3.5.2 Product Data Element Definition

Table 4 provides an overview of the architecture data elements for the Establishment Inventory (HV-4) architecture product.

Table 4: Data Element Definitions for Establishment Inventory (HV-4).

Data Elements	Attributes	Example Values/Explanations
Non-Graphical Box Types		
Establishment	Title	Name of the establishment.
	Location	Location of the establishment.
Reference Types		
Rank	Name	See HV-2 Definition Table.
Career Field		See HV-2 Definition Table.
Occupation		See HV-2 Definition Table.
MOSID		See HV-2 Definition Table.
Job		See HV-2 Definition Table.

4 Linking Human Views to DoDAF

4.1 General

Individual architecture products that comprise DoDAF are not stand-alone entities. Each product depicts a subset of architecture data elements that describe particular aspects of the entire architecture. To that end, relationships exist among the low-level architecture data elements that compose the various products. As such, DoDAF is an integrated architecture (see Section 2.3). Extending DoDAF with the Human View architecture products necessitates a similar definition of relationships between the 'new' HV data elements and the existing architecture data elements. This ensures that DoDAF remains an integrated architecture. Figure 14 illustrates the overall HV extensions to DoDAF.

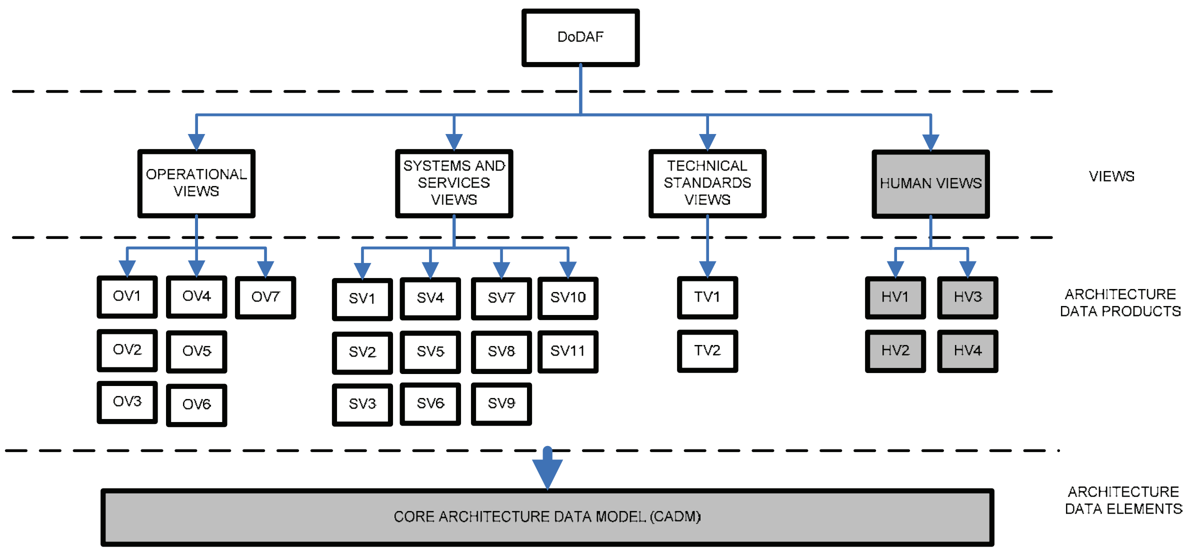

Figure 14: Extending DoDAF with Human Views

The following sections outline linkage between the Human Views and the rest of the DoDAF at three levels: views, architecture products, and architecture data elements.

4.2 Linkages Among Views

The primary linkages describing the interrelationships among the existing DoDAF views and the Human Views are illustrated in Figure 15.[9] Accordingly, the OVs provide the HVs with a breakdown of organizations, operational nodes, and associated operational activities. Conversely, the HVs inform the OVs with the necessary Manpower, Career Progression, and Training requirements to support operational activities as well as career progressions related to operational nodes and organizations. The linkage between SV and HV is characterized by the marriage of system forecasting with the associated manpower predictions.

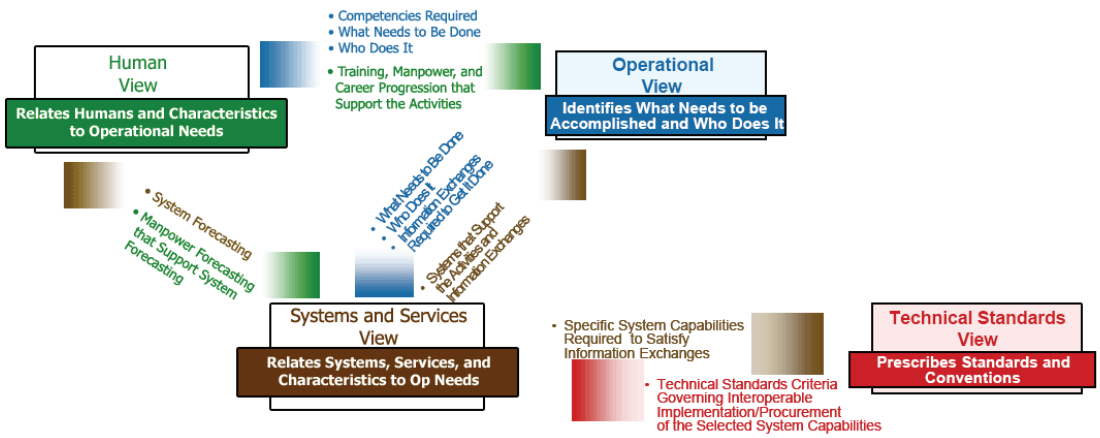

Figure 15: Linkages Among DoDAF Views and Human Views

4.3 Relationships Between Architecture Products

The linkages between views can be further decomposed to illustrate relationships between the architecture products comprising each type of view. Major relationships between the architecture data products as documented in DoDAF Volume I (DoD, 2007a) have been further expanded to illustrate the linkages with the four Human View architecture data products in Figure 16[10]. The numerous linkages between the OVs, SVs, and HVs reinforce the integrated nature of the DoDAF.

As depicted in Figure 16, the following major relationships have been identified:

[9] This figure is an extension of Figure 2-1 Fundamental Linkages Among the Views [4, 5].
[10] Notwithstanding the previous identification of how the HVs relate to the MoDAF Strategic Views in Section 3.

1. HV-3 individual training courses provide military personnel with the necessary competencies and proficiency level to fulfill OV-4 positions within an organization;

2. HV-2 career progression through jobs is accomplished in accordance with the HV3 individual training roadmap;

3. HV-2 jobs perform OV-5 operational activities that are required to support the larger mission objectives;

4. HV-2 jobs within each stage of a career progression map to HV-4 positions within a CF organization;

5. OV-6a rules provide organizational constraints that impact HV-4 establishments;

6. HV-4 establishments and jobs map to OV-4 organizations and positions;

7. HV-4 inventory of manpower by establishments represents a breakdown of the current TES on the HV-1 projection; and

8. HV-1 project phases align with the SV9 forecasting of new program requirements and technologies as well as SV8 systems evolution.

Additional relationships between HV architecture data products and DoDAF may exist and will be identified as these concepts are explored in further detail.

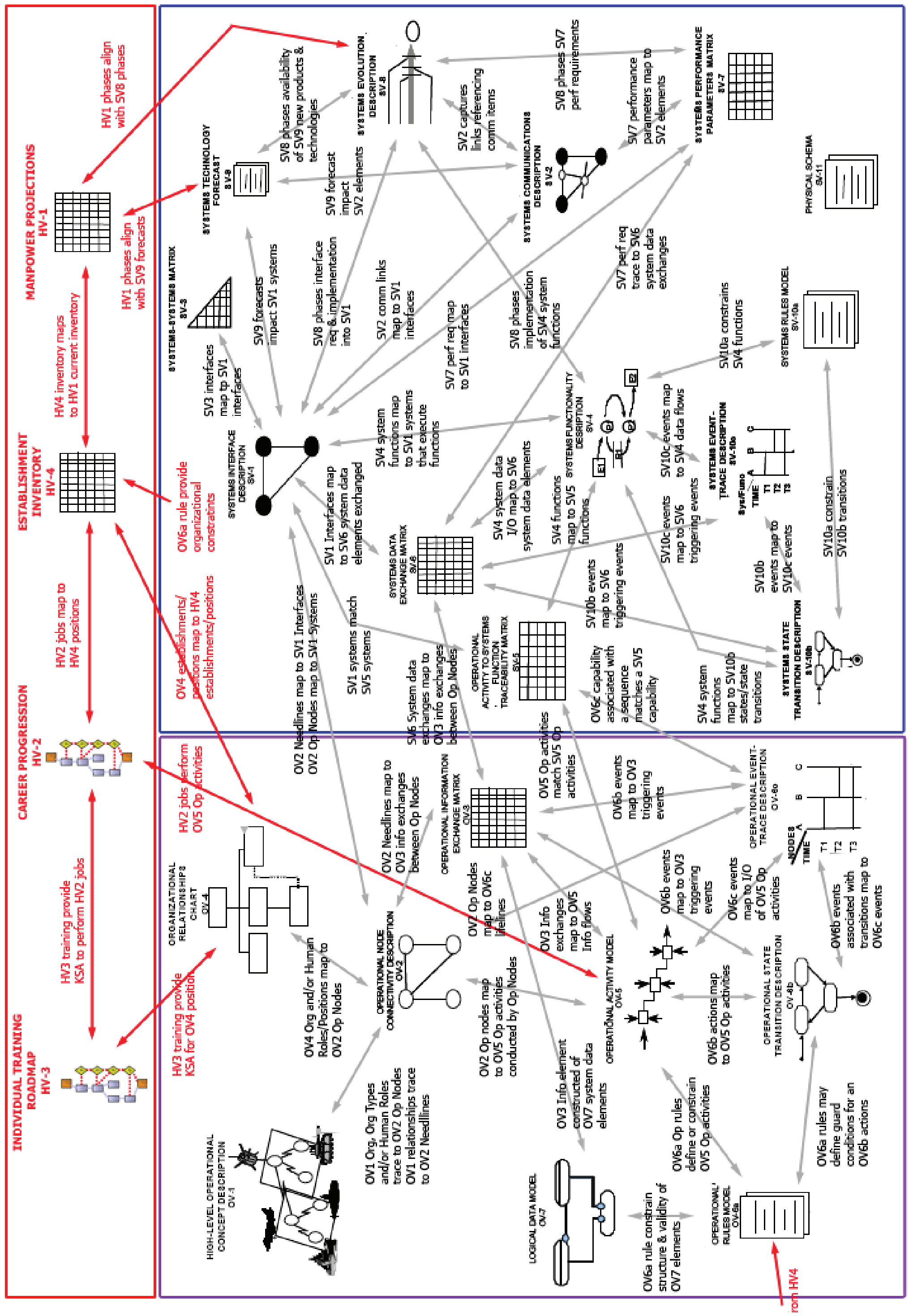

Figure 16: Relationships Between DoDAF and Human Views Architecture Products

4.4 Relationships Between Architecture Data Elements

The DoDAF provides the rules, guidance, and product descriptions for developing and presenting architecture descriptions to ensure a common denominator for understanding, comparing, and integrating architectures. At the lowest level, the CADM provides a common approach for organizing and portraying the structure of architecture information, and is designed to capture common data requirements. As the smallest building blocks within the DoDAF, these CADM elements and their relationships ensure that the higher levels of data abstraction (i.e. views and architecture products) remain integrated. Therefore, linking existing CADM elements with the new HV elements ensure that the proposed HV architecture products are integrated with DoDAF—a key requirement. Figure 17 graphically depicts the CORE schema (i.e., classes and relationships) that constitute the operational, functional, and technical views of DoDAF. Elements have been grouped into four primary categories:

1. Physical elements (pink) represent those elements that perform specific functions and/or produce, consume, or process information.

2. Requirement elements (blue) are statements of direction, requirements (originating, derived), and standards relevant to the architecture.

3. Functional elements (yellow) depict what needs to be accomplished (i.e., processes).

4. Interface elements (green) represent the interconnections physical elements that support execution of the processes.

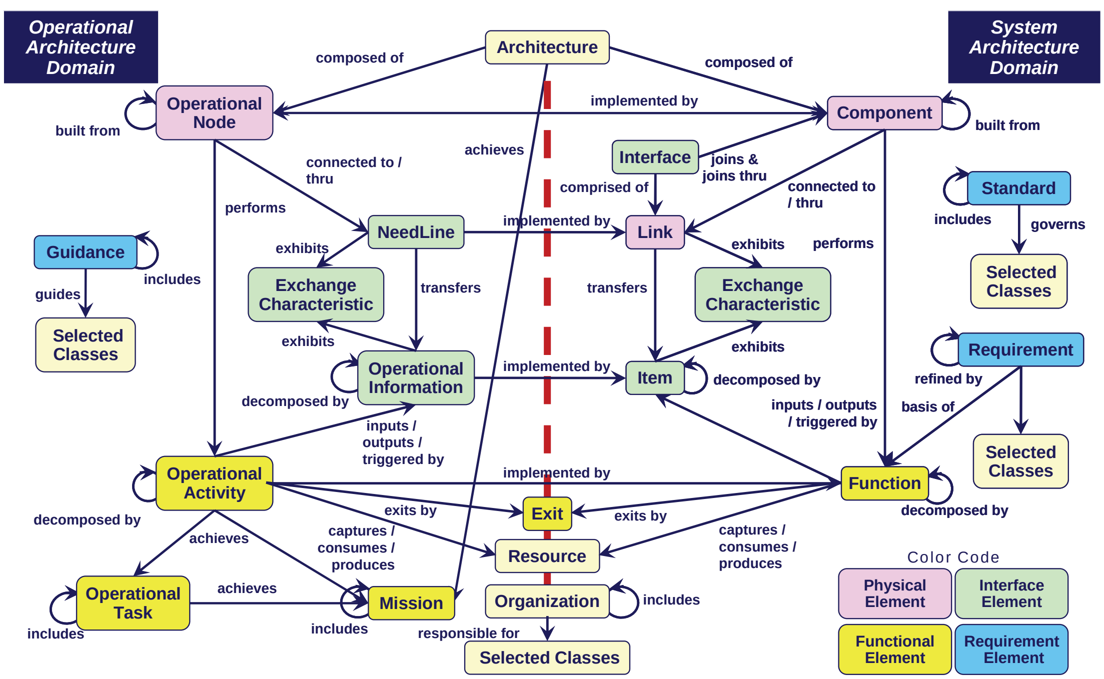

Figure 17: DoDAF Classes and Relationships (Vitech, 2007)

To facilitate the accommodation of HVs, additional human elements were proposed as modification to the underlying schema. Figure 18 depicts a portion of the CADM elements and their relationships (left hand side of Figure 17) along with proposed extensions (orange boxes) for incorporating HVs and thereby enhancing support for a military capability. For instance, an existing CADM element, Operational Node, has been linked to a new HV element, Job, through a relationship labelled "fulfilled by". Furthermore, Jobs are composed of knowledge, skills, and abilities.

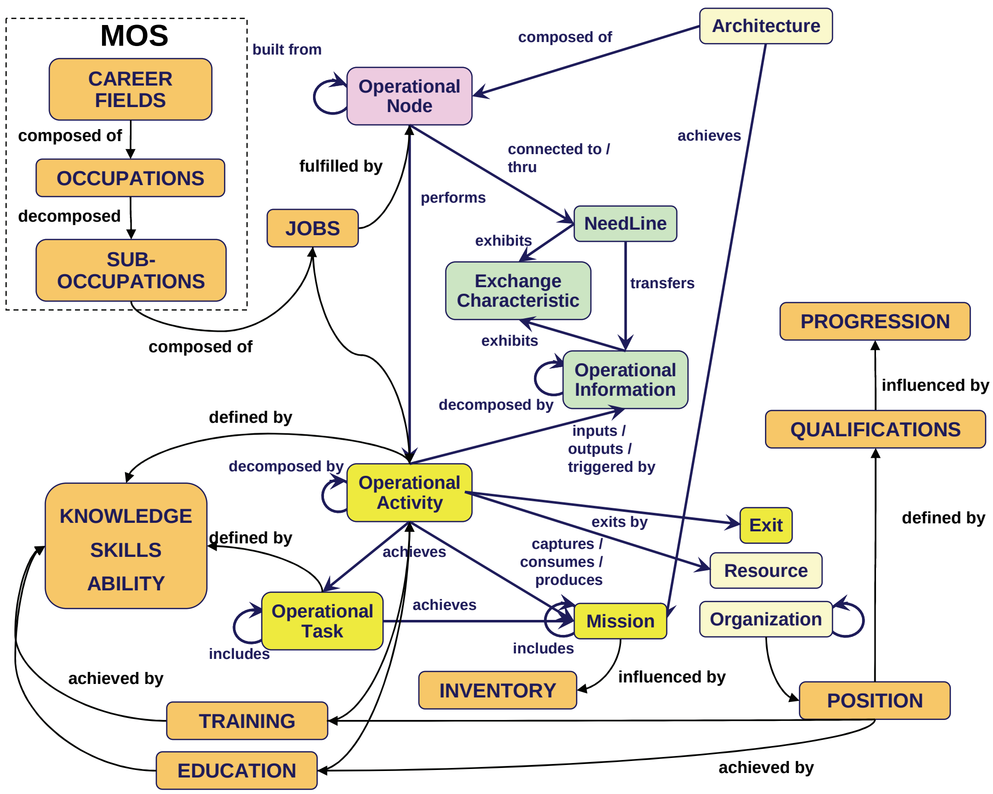

Figure 18: DoDAF and Human View Element Relationships

To demonstrate the feasibility of these proposed extensions, the DoDAF schema within the architecture modelling tool, CORE, was modified to include the necessary HV elements. Figure 19, Class Relationship Matrix, is an output from CORE that illustrates the relationships between all the classes for the modified DoDAF schema (note: given the size of the matrix, it has been cut in half to facilitate representation in the report). The first column represents the classes within the schema and includes the additional HV-specific classes such as Career Fields, Jobs, and MOS. Each black circle denotes a relationship between the two intersecting classes. For instance, Job has a relationship with the target class Operational Activity (relationship – achieved by) since activities/tasks are performed as part of the responsibilities of a given job. Similarly, Jobs are assigned to Organizations since departments, agencies, etc. are comprised of jobs. The extension to the DoDAF in CORE allows data entry, relationships and attributes to be defined and graphical depiction of HVs to be generated while still accommodating the generation of DoDAF views. Consequently, the Human Views articulated in Section 3 have been created.

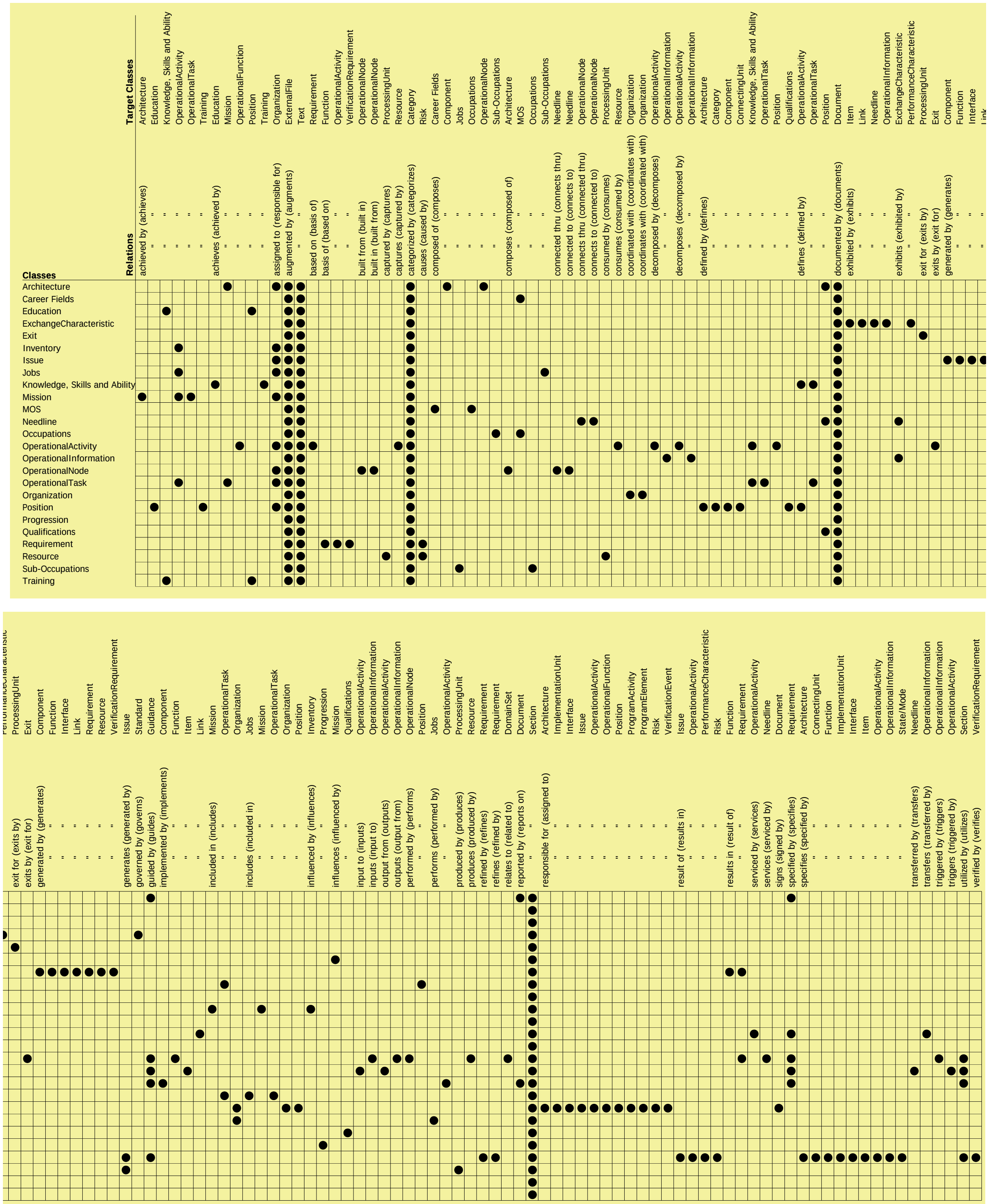

Figure 19: Class Relationship Matrix

5 Application of Human Views

5.1 General

The application of DoDAF and Human View architecture products are best suited to different phases of the defence acquisition strategy. In the US, DoDAF architecture products have been mapped to the Joint Capabilities Integration and Development System. This mapping has been extended to illustrate the potential use of the Human View architecture products to JCIDS.

The following sections provide an overview of JCIDS as well as a mapping of the DoDAF and Human View architecture products to JCIDS. A similar mapping could be conducted with respect to a CF acquisition process; however, to date there has been no direct relationship established between DNDAF and the CF acquisition process. The anticipated adoption of an architecture-based approach within the CBP processes will potentially identify a need to extend the architecture as a direct element of acquisition and therefore presenting HVs within JCIDS is somewhat informative of how this may evolve within DND.

5.2 JCIDS Methodology

The US Department of Defense currently employs three principal decision support processes for transforming the military forces according to the future DoD vision (DoD, n.d.):

1. A Planning, Programming, Budgeting, and Execution process is used to conduct strategic planning and make resource allocation decisions;

2. A Joint Capabilities Integration and Development System is used to determine military capability requirements; and

3. A Defense Acquisition System is used to acquire that capability.

Of particular interest, JCIDS supports the Chairman of the Joint Chiefs of Staff (CJCS) and the Joint Requirements Oversight Council (JROC) in identifying, assessing, and prioritizing joint military capabilities (Figure 20). The capabilities are identified by analyzing what is required across all functional areas to accomplish the mission.

The JCIDS methodology is formally documented in the two manuals CJSCI 3170.01F (CJSCI, 2007) and CJCSM 3170.01C (CJSCM, 2007).

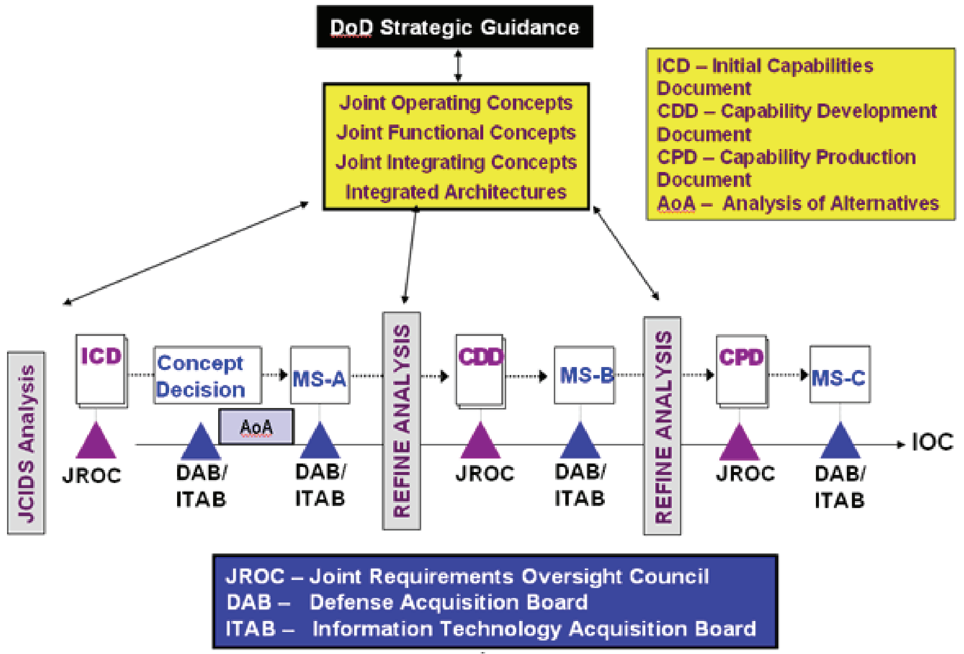

Figure 20: JCIDS Process (DoD, n.d.)

5.2.1 JCIDS Analysis

The JCIDS analysis consists of a four-step methodology aimed at defining capability gaps, capability needs and approaches to provide those capabilities within a specified functional or operational area. Based on national defence policy and centred on a common joint war-fighting construct, the analyses initiate the development of integrated, joint capabilities from a common understanding of existing joint force operations and Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF)[11] capabilities and deficiencies.

Specifically, the four steps comprising the JCIDS analysis are:

1. **Functional Area Analysis (FAA).** At a macro level, the objective of the FAA is to characterize and prioritize the capabilities, operational tasks, and conditions required to accomplish military objectives. *FAA output* – Tasks to be accomplished.

2. **Functional Needs Analysis (FNA).** The FNA assesses the ability of current and programmed capabilities to accomplish the military objectives. This leads to the identification and definition of conceptual new capabilities that are aligned with strategic priorities. These needs are capabilities for which solutions must be found or developed. *FNA output* – List of capability gaps.

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[11] The DND equivalent to DOTMLPF is Personnel, R&D and Operations Research, Infrastructure and Organization, Concepts, Doctrine and Collective Training, IT Infrastructure, Equipment (PRICIE)

3. **Functional Solution Analysis (FSA).** The FSA identifies candidate solutions for filling capability gaps defined by the FNA, including non-materiel changes, changes in quantity of existing materiel, product improvements to existing materiel or facilities, adoption of other service or interagency solutions, acquisition of foreign materiel and new materiel acquisition. The FSA compares alternatives to determine the most effective solutions. *FSA output* – Potential integrated DOTMLPF approaches to capability gaps.

4. **Post Independent Analysis (PIA).** The PIA is an independent analysis of approaches to determine the best fit for potential solutions. The individuals performing the PIA are not the same individuals involved in the FSA. *PIA output* – Initial Capabilities Document.

5.2.2 JCIDS Documentation

As part of the overall JCIDS process, the following key deliverables are generated:

1. **Joint Capabilities Document (JCD).** The JCD captures the FAA and FNA results. In turn, the JCD can be utilized as a baseline to support the analyses of the gap(s) (i.e., FSA and PIA);

2. **Initial Capabilities Document (ICD).** The ICD documents the need for a materiel and/or non-materiel approach for satisfying the capability gaps identified during the FNA;

3. **Capability Development Document (CDD).** The CDD supports the development of proposed programs through an evolutionary acquisition strategy. To that extent, the CDD will outline a strategy for an incremental evolution of a capability that can be supported by the military. Each increment is "a military useful and supportable operational capability that can be effectively developed, produced or acquired, deployed and sustained" (CJSCI, 2007); and

4. **Capability Production Document (CPD).** The CPD addresses the necessary production attributes and quantities specific to each individual increment of an acquisition program.

5.2.3 Analysis of Alternatives (AOA)

The AOA involves a comparative analysis of the performance, operational effectiveness, operational suitability, and estimated Life-Cycle costs of alternative solutions to meet the capability needs. Initially, this process is exploratory whereby numerous conceptual solutions are presented and the most promising options are identified. Subsequently, the AOA serves to justify the rationale for a formal initiation of an acquisition program.

The AOA is a key input to defining system capabilities housed in the CDD.

5.3 Application of Architecture Products

5.3.1 Overview

Integrated architectures play an important role with executing the JCIDS methodology. DoDAF Volume I (DoD, 2007a) provides a comprehensive overview regarding the application of the DoDAF architecture products (AV, OV, SV and TV) to each phase of the JCIDS process. Similarly, the JCIDS documentation (CJSCI, 2007; CJSCM, 2007) explicitly states the contribution of DoDAF architecture products to the JCIDS documentation. This mapping is summarized in Table 5 and has been extended to illustrate the application of the proposed HVs to JCIDS. The following legend applies to the table:

1. A light grey cell indicates the product is required to achieve an integrated architecture;

2. A dark grey cell indicates the product is specified in policy;

3. A solid black circle indicates the product is highly applicable to the indicated use;

4. A white circle with a centre black dot indicates that the product is often or partially applicable; and

5. A blank cell indicates that the product is usually not applicable.

Table 5: Mapping DoDAF Architecture Products to JCIDS

DoDAF View	DoDAF Architecture Product		JCIDS Phase		
			Analysis	**Document**	**AOA**
ALL VIEW	AV-1	Overview and Summary Information	●	●	●
	AV-2	Integrated Dictionary	●	●	●
OPERATIONAL VIEW	OV-1	High-Level Operational Concept Graphic	●	●	●
	OV-2	Operational Node Connectivity Description	●	●	●
	OV-3	Operational Information Exchange Matrix	⊙	●	⊙
	OV-4	Organizational Relationships Chart	⊙		
	OV-5	Operational Activity Model	●	●	●
	OV-6a OV-6b OV-6c	Operational Rules Model Operational State Transition Operational Event-Trace Description	●	●	●
	OV-7	Logical Data Model			
SYSTEMS AND SERVICES VIEW	SV-1	Systems/Services Interface Description	●	●	●
	SV-2	Systems/Services Communications Description	⊙	⊙	⊙

DoDAF View	DoDAF Architecture Product		JCIDS Phase		
			Analysis	**Document**	**AOA**
	SV-3	Systems-Systems Matrix Systems-Services Matrix Services-Services Matrix		⊙	⊙
	SV-4a SV-4b	Systems Functionality Description Service Functionality Description	⊙	●	●
	SV-5a SV-5b SV-5c	Op Activity to Systems Function Traceability Matrix Op Activity to Systems Traceability Matrix Op Activity to Services Traceability Matrix	●	●	●
	SV-6	Systems/Services Data Exchange Matrix		●	⊙
	SV-7	Systems/Services Performance Parameters Matrix		⊙	⊙
	SV-8	Systems/Services Evolution Description		⊙	⊙
	SV-9	Systems/Services Technology Forecast		⊙	⊙
	SV-10a SV-10b SV-10c	Systems/Services Rule Model Systems/Services State Transition Descr. Systems/Services Event-Trace Description		●	
	SV-11	Physical Schema			
TECHNICAL STANDARDS VIEW	TV-1	Technical Standards Profile	⊙	●	⊙
	TV-2	Technical Standards Forecast		⊙	⊙
HUMAN VIEW	**HV-1**	**Manpower Projections**	●	●	●
	HV-2	**Career Progression Roadmap**	●	●	●
	HV-3	**Individual Training Roadmap**	●	●	●
	HV-4	**Establishment Inventory**	⊙	⊙	⊙

The following sections highlight the contributions of both the existing DoDAF products (condensed version as per DoD, 2007a) as well as the proposed HV architecture data products to the JCIDS analysis effort, JCIDS documentation, and Analysis of Alternatives. In this manner, the value proposition of HVs in supporting acquisition-related decisions is highlighted, and conceptually, HVs would provide key information sources for consideration by decision makers in developing long term capability plans that have a significant acquisition element (i.e., the impact of an acquisition in terms of personnel training requirements and career progression will potentially be addressed much earlier and thereby provide increased trade-off considerations).

5.3.2 JCIDS Analysis

DoDAF architecture data products are currently integrated into the overall JCIDS analysis effort to assist with its execution during each phase. A conceptual application of the proposed HVs is added to represent their contribution to the JCIDS analysis.

5.3.2.1 Functional Area Analysis

Architecture products assist with the identification of the operational tasks, conditions, and standards that are required to achieve the desired military objectives. This support includes:

1. OV-5 in conjunction with Universal Joint Task Lists (UJTLs) (CJSCM, 2002)[12] provide insights into tasks that are required to accomplish military objectives;

2. OV-6 provides critical timing and sequence attributes and documents operational threads; and

3. SV-5 provides a basis for identifying activities (and associated capabilities) not supported by existing materiel solutions.

5.3.2.2 Functional Needs Analysis

As part of the FNA, architecture products help to assess the ability of current and programmed joint capabilities to accomplish the tasks generated during the previous FAA (i.e., identify capability gaps). This support includes:

1. OV-2 identifies key operational nodes and operational information exchange requirements for tasks/activities of interest;

2. SV-2 provides the basis for identifying existing connectivity;

3. SV-5 and SV-1 identify areas where required system functions are not provided by any system or where the same system function is provided by multiple systems; and

4. HV-1 in conjunction with HV-4 identifies manpower gaps that cannot be supported with current military personnel.

5.3.2.3 Functional Solution Analysis

To support the assessment of potential DOTMLPF and/or policy approaches to addressing capability gaps identified during the FNA, the OV, SV, and HV architecture elements provide the basis for conducting an options analysis with respect to the DOTMLPF attributes. Specifically, the Manpower/Personnel axis can be addressed in the following manner:

1. HV-1 provides the ability to conduct strategic manpower trade-offs and comparison between potential options;

2. HV-2 identifies the impact on personnel issues including career progression and promotions as well as the associated costs; and

3. HV-3 identifies the impact on training programs and associated costs.

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[12] The Universal Joint Task List serves as a common language and common reference system for joint force commanders, combat support agencies, operational planners, combat developers, and trainers to communicate mission requirements.

5.3.2.4 Post Independent Analysis

Given that the objective of the PIA is to assess the FSA results independently, no additional contributions by integrated architecture products are required.

5.3.3 JCIDS Documentation

Joint Capabilities Integration and Development System Process (CJSCM, 2007) explicitly outlines the architecture products that are necessary for satisfying the requirements for each of the four JCIDS deliverables. The contributions afforded by the HVs have been included to represent their added value to the JCIDS documentation effort.

5.3.3.1 Joint Capabilities Document

While other DoDAF architecture products are desirable, only the OV-1 is required for the submission of the JCD. Since the JCD describes the results from the FAA and FNA, the HV-1 architecture product would also play a role with identifying gaps related to manpower in support of achieving capabilities.

5.3.3.2 Initial Capabilities Document (ICD)

Similar to the JCD, only the OV-1 architecture data product is mandated for inclusion in the ICD deliverable.

Although, the ICD will describe the key boundary conditions and operational environments that impact the employment of a system to satisfy the mission need. Key boundary conditions that may have a major impact on system performance and lifecycle cost include HSI domains (e.g., manpower, personnel, training, safety, HF, health hazards). To assess these domains early in the capability development process, the HV architecture data products play a role in understanding conditions, formulating strategies, and assessing trade-offs.

5.3.3.3 Capability Development Document

In accordance with JCIDS process documentation (CJSCM, 2007), the formulation of the CDD deliverable includes a series of architecture data products (AV-1, OV-1, OV-2, OV-4, OV-5, OV-6c, SV-2, SV-4, SV-6, SV-7). In addition, the CDD needs to specify HSI capabilities. With respect to manpower, the CDD should identify any constraint that may impact the utility of a project. To that extent, the HV-1 and HV-4 architecture products assist with determining the impact of constraints such as the cap imposed by the Total Paid Strength. This will ensure manpower thresholds are not exceeded and additional manpower resources are not taken away from higher priority projects that are later in their acquisition process. The CDD will also discuss specific system training requirements to support the instantiation of a given capability. HV-3 supports the trade-off analyses that can be conducted to assess potential training strategies to meet the mission objective. A discussion of the analyses and/or results conducted to determine the HSI capabilities should be contained in HSI programmatic documentation (e.g., HSI plan, Training Systems plan, or Manpower Estimate).

5.3.3.4 Capability Production Document

A series of architecture products (AV-1, OV-1, OV-2 OV-4, OV-5, OV-6c, OV-7, SV-2, SV-4, SV-5, SV-6, SV-11, TV-1) are developed in support of generating the CPD. In addition to these products, HV-1, HV-2 and HV-3 should be delivered as part of the CPD to articulate the HSI-related issues surrounding a single increment of a specific system.

5.3.4 Analysis of Alternatives

As part of the AOA, the integrated architecture data products assist with comparing different strategies and solutions to address capability gaps. As such, the HV architecture data products allow decision makers to perform comparative analyses based on costs related to HSI issues such as personnel, manpower, career progression, and recruiting.

6 Multi-Mission Effects Vehicle Use Case

To illustrate the utility of the HVs to a CF acquisition, a conceptual application of the HV architecture products to the Multi-Mission Effects Vehicle (MMEV) TDP[13] is presented in the following sections.

6.1 Background

The Canadian Land Forces (LF) are investigating a concept, the MMEV, which integrate into a single platform three traditionally separate functions:

1. Direct fire – engage targets directly through line of sight (LOS) munitions;

2. Precision non-line of sight (NLOS) – engage targets through precision NLOS munitions; and

3. Ground-based air defence (GBAD) – act as the main GBAD for the Canadian LF.

The introduction of the MMEV will have a significant impact on the composition of a future Combat Team within the CF. To that end, the introduction of the MMEV into the LF introduces a series of areas that require further investigation, including:

1. Determine battlefield effectiveness of capability and effectiveness of individual technologies;

2. Investigate concept of operations in complex and open terrain;

3. Refine the Army Force Employment Concept;

4. Explore C2 Intelligence at the lowest tactical level;

5. Design, build and assess design options;

6. Assess crews' human performance to optimize battle effectiveness and to provide preliminary data to analyze the impact on recruitment, training, and MOC structure;

7. Explore interoperability issues and technological implications; and

8. Assess ability to operate with a two and three-man crew as opposed to a four-man crew.

[13] Originally, the use case to be investigated as part of the HV work was the Multi-Role Combat Vehicle (MRCV). At that time, the MRCV was simply the next instantiation of the MMEV. However, the MRCV has since evolved in a different direction from its original roots with MMEV. As such, the use case presented in this report has reverted back to the MMEV.

6.2 Results of the MMEV Study

The introduction of new capabilities afforded by the MMEV inherently leads to the design of new operator machine interfaces as well as definition of user requirements. Additionally, the transformation in crew size can be studied through analyses focusing on workload and performance prediction. To support these analyses, a Mission Function Task Analysis (MFTA) was undertaken to collect and synthesize the necessary data. A MFTA, as defined by MIL-HDBK-46855 (DoD, 1999), is comprised of the following three interdependent analyses:

1. **Mission analysis** defined the missions of the system, and the environment and circumstances in which these missions must be conducted. Each distinct event in the mission from the point at which human interaction with the system commences until human interaction terminates is considered. The analysis focuses on the major mission phases and functions, the timescale of activities, and external events which influence the activities of the system.

2. **Function analysis** identified the functions (and sequence of functions) that must be performed by the system being analyzed to achieve mission objectives. This analysis involves a functional decomposition of the missions from top-level down to lowest-level functions, thereby yielding a hierarchical inventory of functions (Figure 21). The lowest-level function is referred to as a task, whereby a task is defined as a specific human activity with a unique set of performance characteristics.

3. **Task analysis** developed a database of task data elements for each unique task generated during the Function analysis.

The output from the MMEV MFTA and subsequent workload analysis resulted in a crew composition of three:

1. The Crew Commander (CC) will be senior in rank or experience with overall command and responsibility for the MMEV. The CC is also capable of operating all Fire Control Systems (FCS);

2. The Deputy Crew Commander (DCC) is responsible to the CC and is also capable of operating all FCS within the MMEV; and

3. The Driver is responsible for driving and navigating the vehicle as well as performing basic maintenance on the vehicle.

Responsibilities in the form of functions and tasks have been allocated to each MMEV crew member. In addition, a set of competency requirements (e.g., KSA) has also been assigned.

To date, the MMEV TDP has focused on utilizing HSI data elements to support the generation of innovative operator machine interfaces (OMI) as well as the conduct of a series of lab evaluations. While not the focus of the MMEV TDP, the introduction of the MMEV into the CF introduces a myriad of issues related to the HSI domains that requires resolution. Specifically, this LF transformation impacts manpower, personnel, and training within the Combat Arms career field.

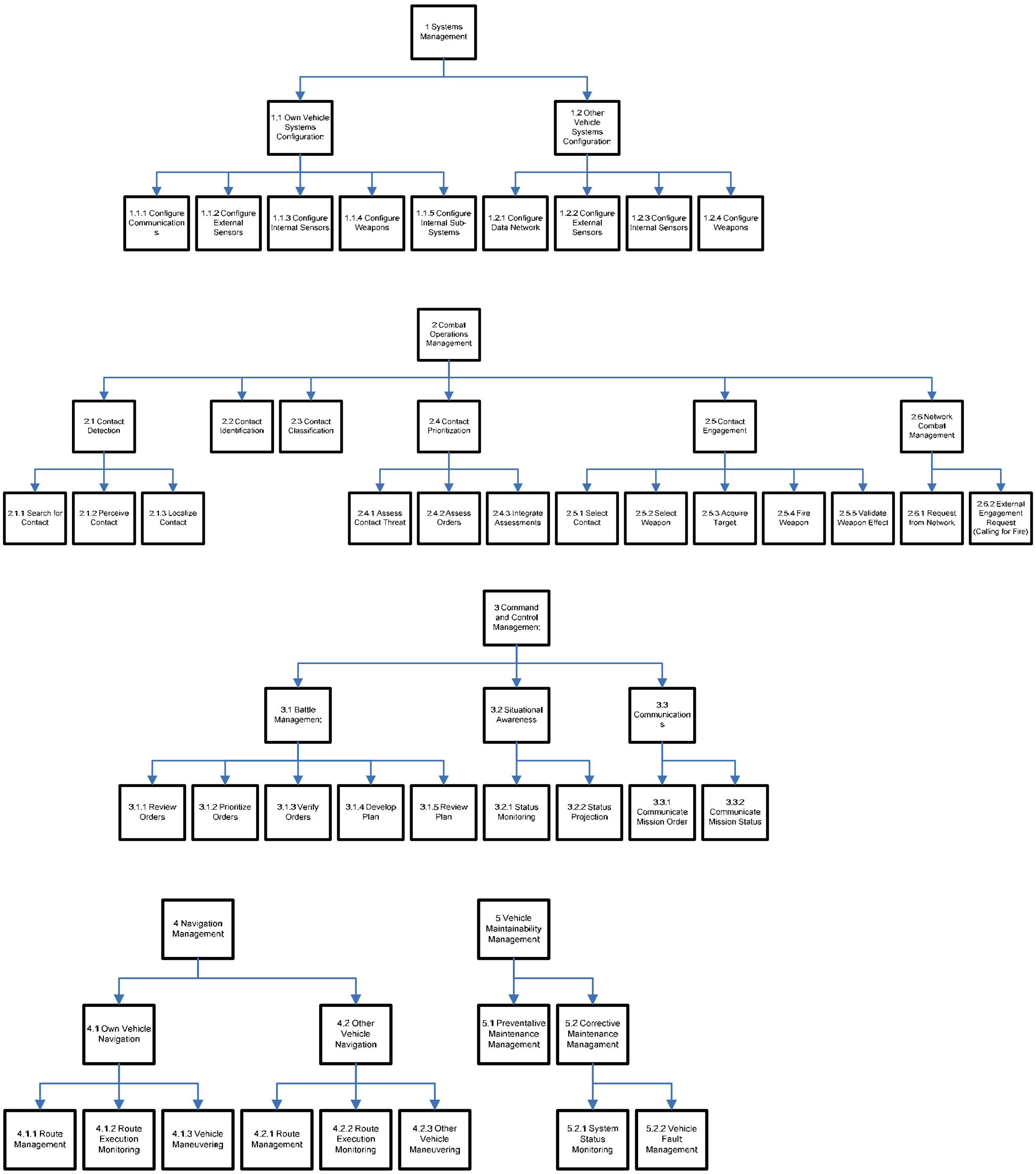

Figure 21: MMEV Functional Decomposition

6.3 Problem Space

Currently, career progression and functional training for the Combat Arms career field is bounded by three occupations: Infantry, Armoured, and Artillery. Each occupation is divided into sub-occupations with individual specialities as represented in Table 6.

Table 6: Combat Arms Career Field.

Occupation	Sub-Occupation	Description
Infantry	Dismounted Fire Support	A forward observer takes up a position where he can observe the target using tools such as binoculars and laser range-finders and designators and call back fire missions.
	Line of Fire	Engaging targets using LOS munitions.
Armoured	RECCE	Location Active gathering of information about an enemy (e.g. location, identification of high-value targets) through observation of the establishment.
	Direct Fire	Engaging targets using LOS engagements.
Artillery	Air Defence	Engaging aircrafts with surface-to-air munitions.
	Field Artillery	Engaging targets through beyond line of sight munitions.

For each of these occupations, there is a specialized platform tailored to suit the respective roles and responsibilities. For example, personnel within the AD Artillery occupation are trained to operate, maintain, and sustain the Air Defence Anti-Tank System (ADATS).

While the above MOS for the Combat Arms career field addresses the current LF force structure, the MMEV crosses the existing occupational boundaries since this vehicle will possess capabilities to conduct the following:

1. Direct fire traditionally handled by the DF armoured occupation;

2. GBAD under the responsibility of the AD artillery occupation;

3. LOS handled by the LOS infantry occupation; and

4. NLOS under the responsibility of the FD artillery occupation.

Figure 22 depicts this transition from the AS-IS state to the TO-BE state for the Combat Arms career field with the inclusion of the MMEV. As illustrated, the Main Battle Tank (MBT) is to be replaced by the MGS and the ADATS is to be phased out. In addition, a new CF capability (precision NLOS) is being introduced with the MMEV. Therefore, the current Combat Arms framework will have to be revamped to address these cross-boundary competencies required by the MMEV crew.

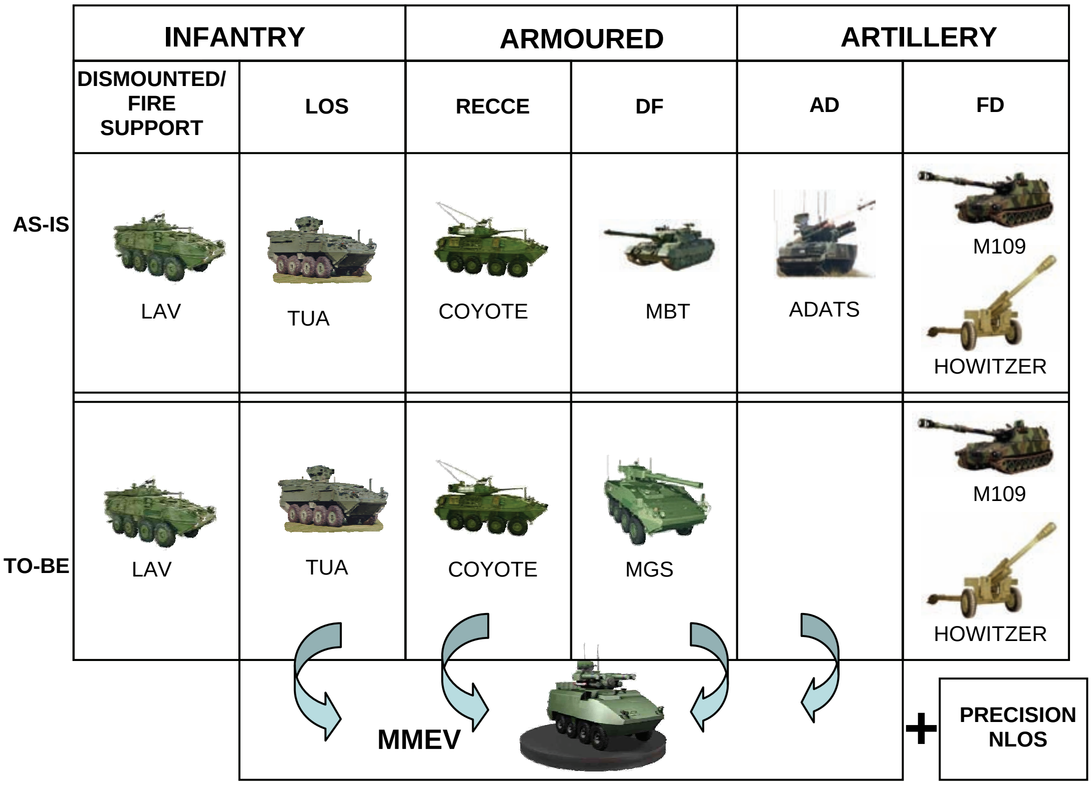

Figure 22 : MMEV Transformation

The combat team mechanized infantry will also see a radical change (Figure 23). The current combat team is comprised of four tank troops and one infantry platoon as well as a forward observation officer (FOO) and engineering support. The proposal is to replace the four tank troops with two MGS troops, one MMEV troop, and one Tow Under Armour (TUA). Despite the change in platform composition, the combat team mechanized infantry will maintain a similar functional capability.

In addition to the evolution of the combat team mechanized infantry, the MMEV crew will be reduced from a conventional composition of four operators (i.e., CC, Loader, Gunner, and Driver) to three operators (i.e., CC, DCC, and Driver). Each position in the conventional crew is responsible for a specific role with respect to the overall capabilities of the existing platforms (i.e., the Driver is responsible for driving the vehicle). However, the MMEV crew concept will employ two operators (i.e., CC and DCC) equally capable of independently operating the systems (i.e., sensors and weapons) within the MMEV. In this concept, the MMEV will require a DCC instead of the traditional Gunner. The CC and DCC will operate the vehicle as a team sharing the tasks of target detection, acquisition, identification and engagement. Within this model, a more equal authority between the two operators is assumed as compared to previous armoured systems. Considering the MMEV is also a complex system, its design must rely on the maximum exploitation of the crews' capability and therefore both the CC and DCC will be highly experienced individuals, equally capable of independently operating the MMEV systems.

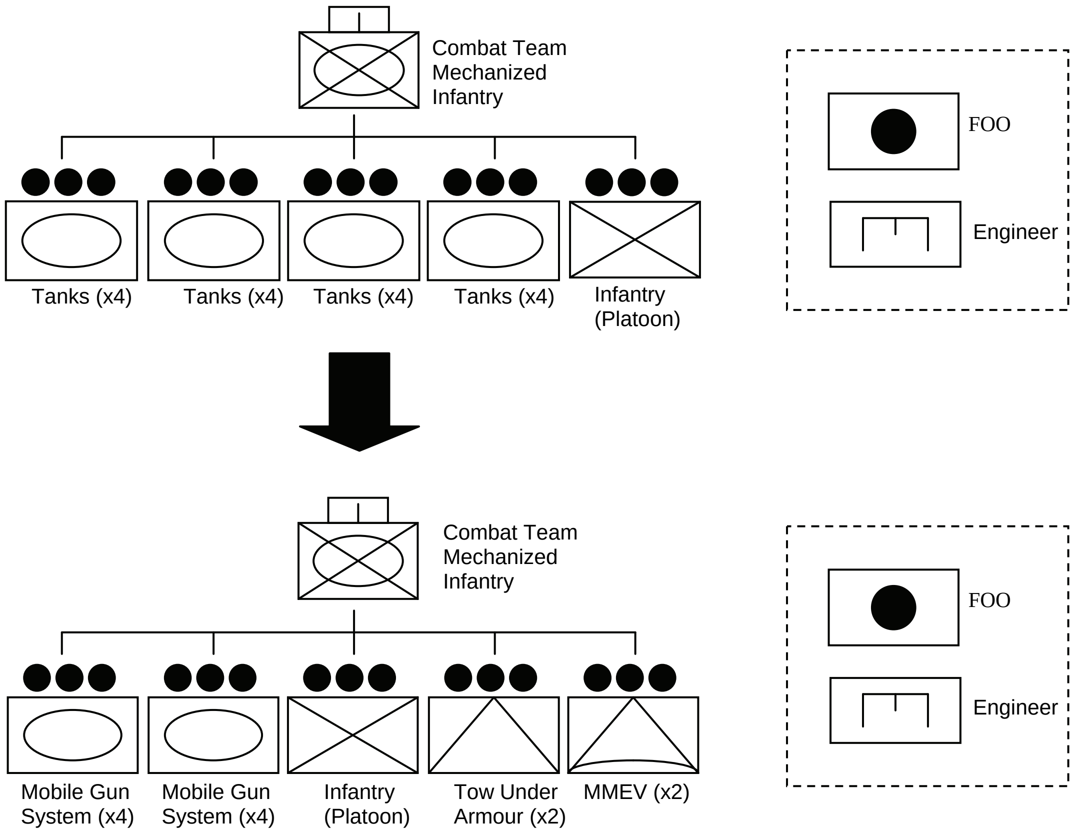

Figure 23: Combat Team Mechanized Infantry Transformation

In contrast to typical armoured systems, the MMEV Driver will be cross-trained on the operation of the MMEV FCS. As such, the Driver will be available to assume duties and responsibilities of the DCC or CC during sustained operations. To support this role, Driver training will have to be sufficiently in-depth in order for Drivers to be effective at operating the FCS to an adequate proficiency level.

Careers (and subsequent training) also follow a natural progression from Driver to Gunner to Loader to Crew Commander. The future crew composition breaks down these traditional training paths whereby crew members will be trained to perform tasks from multiple existing jobs within different occupations (Note: This notion becomes feasible as many of the current functions are being investigated for potential automation.)

6.4 Solving the Problem

6.4.1 General

As mentioned in the previous section, the integration of the MMEV into the Canadian LF will impact the existing CF force structure. As part of the MMEV acquisition process, the goal is to determine at the outset the nature and extent of these impacts in order to develop efficient solutions, both in terms of operational capability and cost effectiveness. As such, integrated architectures (such as DoDAF) are used to systematically structure and understand the AS-IS state as well as to facilitate the identification and quantification of these impacts.

The following sections illustrate the application of the HVs to help address issues surrounding Manpower, Career Progression, and Training accompanying the acquisition and subsequent fielding of the MMEV. From a holistic standpoint, this involves comparing Human Views for the existing CF force structure (AS-IS state) against the requirements imposed by the inclusion of the MMEV. Analysts within each of the HSI domains (i.e., training, human factors, manpower/personnel, system safety, health hazards) can then identify impacts within their area of responsibility as well as model and compare potential solutions through the creation of new Human Views for the target capability (TO-BE state).

A portion of the processes presented in this case study are currently used by the CF. However, in many cases collaboration across HSI domains is not done despite the reliance on similar data sets. Therefore, another benefit of architectures is to facilitate the sharing of information among diverse stakeholders.

6.4.2 Manpower

With respect to the manpower domain, decision makers must address questions such as:

1. Will the required operator, maintainer and support personnel with the necessary KSA be available?

2. Will new recruits be required? Or will the existing pool of military personnel accommodate the MMEV?

3. Has the impact of the MMEV on force structure during replacement or “phase in” been determined?

4. Does the MMEV require more, same, or fewer people than the predecessor system(s)?

To address these questions, an examination of the HV-1 architecture product would allow decision makers to perform an assessment of the MMEV manpower requirements within the larger context of the CF capabilities thereby taking into account existing operational systems and other projects potentially coming on-line or going off-line. In addition, these assessments can be done in consideration of financial constraints such as TPS whereby military personnel may have to shift from other areas to support fielding of the MMEV. Or if this solution is not feasible, one or more project timelines could be shifted to accommodate any manpower limitations.

For instance, Figure 24 depicts a notional HV-1 architecture product where upon further inspection a capability manager may notice that a pool of artillery personnel will be available two years prior to IOC for the MMEV due to the decommissioning of the ADATS. If the TPS for the CF remains fixed for this timeframe, the demand for the MMEV operators and maintainers would have to be satisfied through the supply of available ADATS personnel or another similar resource pool. Analysing the HV-4 establishment inventories currently housing ADATS personnel would provide additional insights into the location and availability of these candidate MMEV personnel operators. As such, costs that may be incurred (e.g., costs for moving personnel) if the ADATS operators need to be transferred to another establishment to support MMEV operations can be determined.

As a next step, a more detailed investigation would be required to determine the level of compatibility between the existing competencies of the ADATS operators and the required competencies of the MMEV operators (see next section).

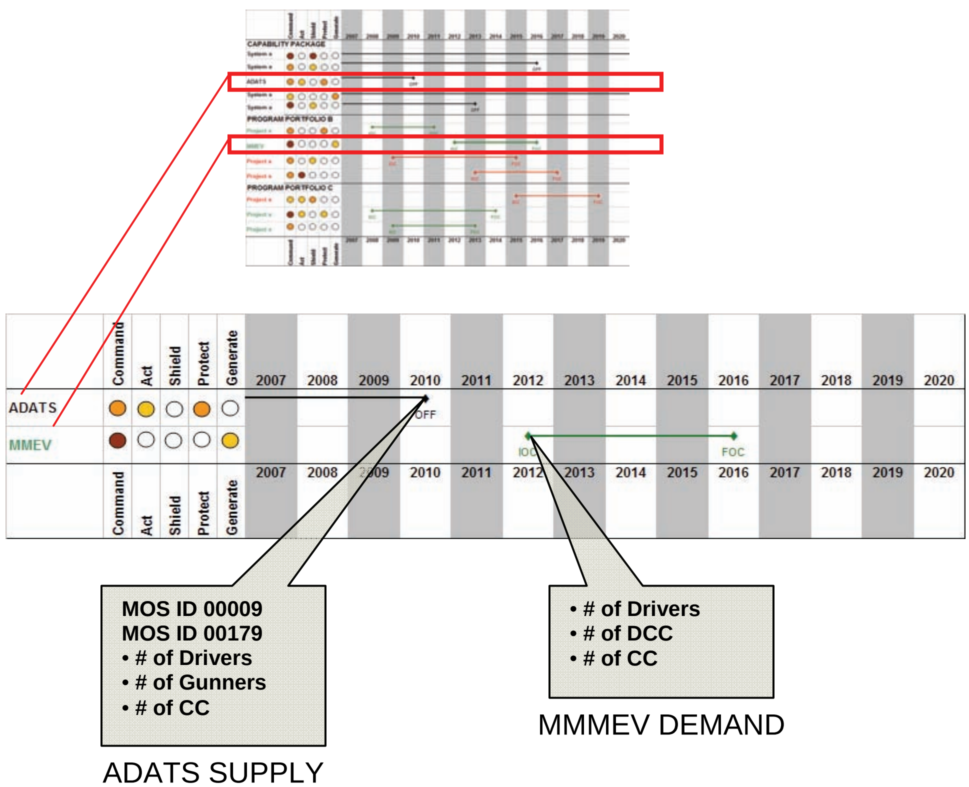

Figure 24: Notional HV-1 MMEV Architecture Data Product

HV-4 architecture products for LF establishments with artillery components would reveal more details regarding the current makeup of artillery personnel. These establishments would include CFB Shilo (1st Regimental Royal Canadian Horse Artillery), CFB Petawawa (2nd Regimental Royal Canadian Horse Artillery), CFB Valcartier (5e Régiment d'artillerie légère), and CFB

Gagetown (4th Air Defence Regiment). The latter establishment would provide specifics related to the CF ADATS personnel.

6.4.3 Career Progression

The new MMEV crew members will also require resolution of questions related to career advancement including:

1. What is the career advancement roadmap to become a MMEV crew commander or deputy commander? What opportunities are available subsequently?

2. Which occupation will support the MMEV career path?

3. What competencies are required to perform the new MMEV jobs?

4. Are there enough individuals within the career path at lower jobs that will have the necessary competencies to advance in order to meet the fielding of the MMEV jobs?

5. What is the impact to the rank structure within the Combat Arms career field?

A troop of MMEVs (2 or 3 MMEV) would be under the command of a CC in the lead vehicle. The MMEV Troop Leader job would be staffed by an officer whereas NCMs would staff the crew positions for all remaining MMEVs in the troop. Career progression through DPs is managed differently for officers as compared to NCMs. Figure 25 and Figure 26 illustrate representative career progression opportunities for an FD Artilleryman NCM (MOSID 00008) and an Artillery Officer (MOSID 00179) within the AS-IS regimental system for the CF. The MMEV crew concept lends itself to the Troop Leader progressing through a similar career stream to the existing Artillery Officer; whereas, the remaining MMEV positions would follow a NCM career stream comparable to the FD Artilleryman.

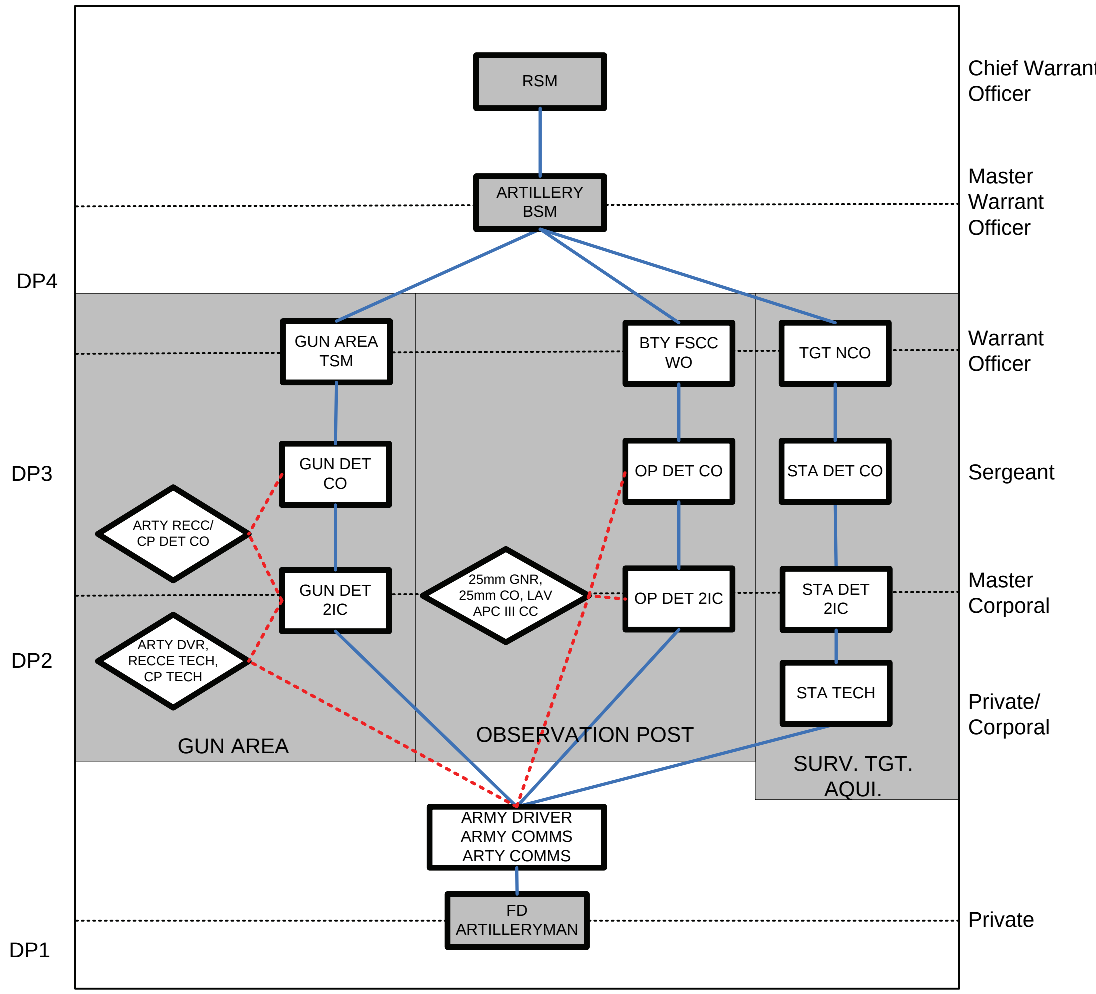

Figure 25: HV-2 Architecture Data Product for Field Artilleryman (AS-IS)

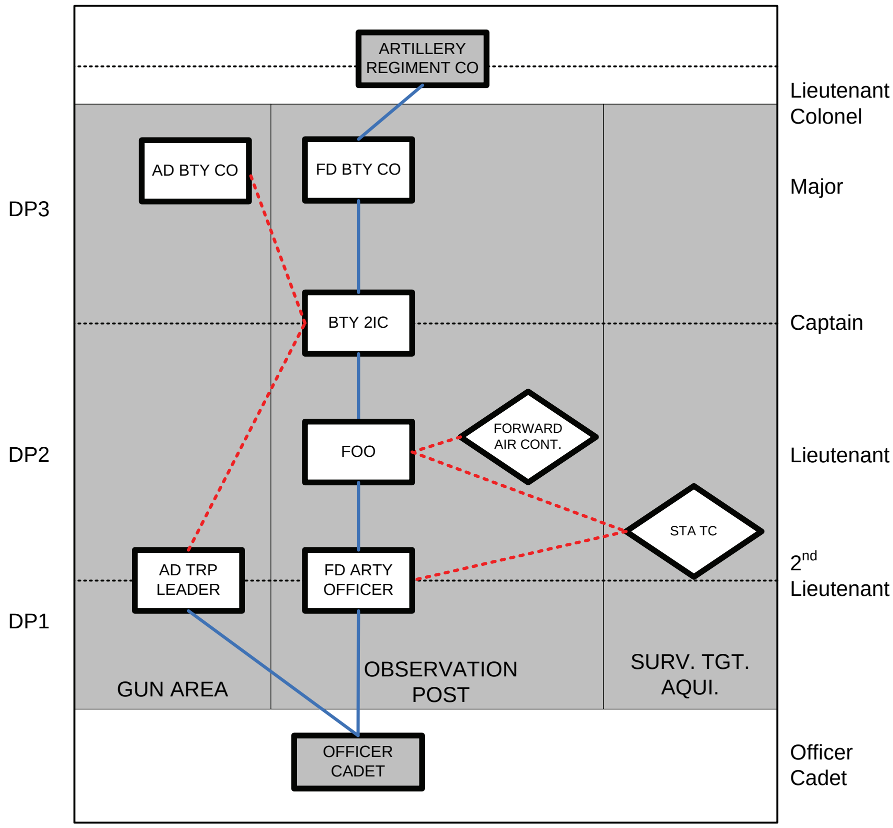

Figure 26: HV-2 Architecture Data Product for Artillery Officer (AS-IS)

To determine the impact of the MMEV crew on the AS-IS career streams, a comparison between these career streams and MMEV requirements is done. The MMEV MFTA revealed a set of tasks as well as KSA for each of the three MMEV crewmembers. Due to the increase in system capability, it is expected that the overall crew requirements will correspondingly increase as compared to traditional Army fighting vehicles. Figure 27 depicts the nature of the analysis whereby the MMEV Troop Leader derived competencies would be compared against the competencies of jobs within the Artillery and Armoured Officers. In this case, MMEV Troop Leader competencies are compared with those related to the armoured jobs of Recce Troop Leader and DF Troop Leader as well as the artillery jobs of AD Troop Leader and FD Artillery Officer. A similar comparison would also be made against the LOS Infantry occupation.

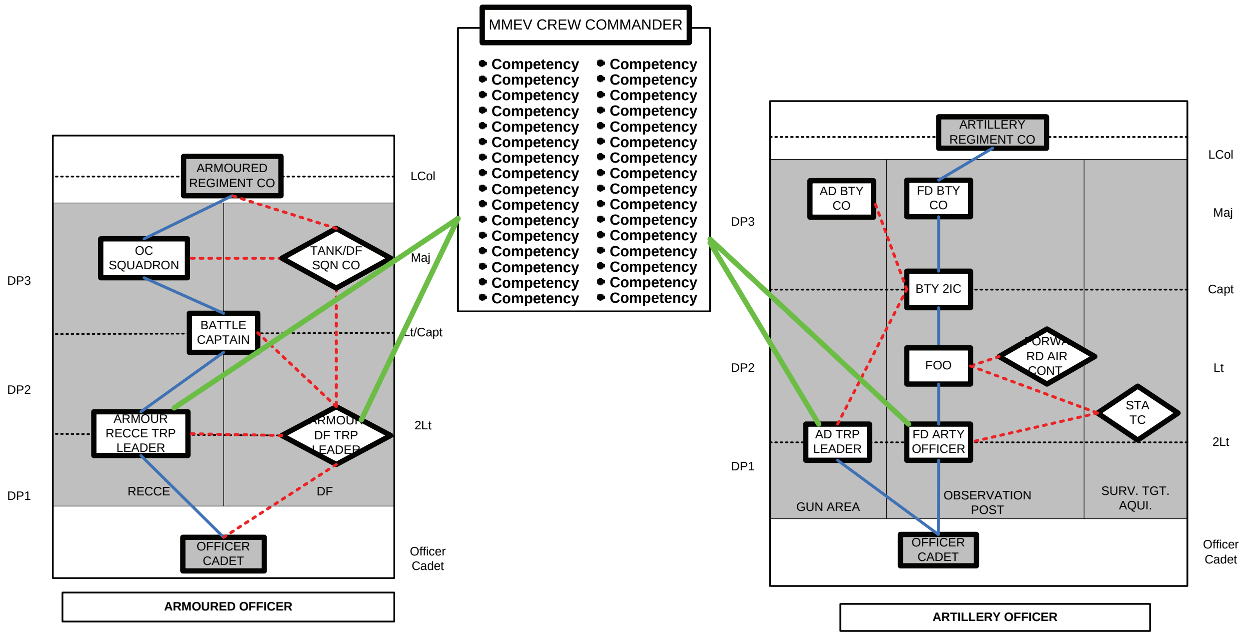

Figure 27: Comparing MMEV Troop Leader Competencies to Existing Jobs

Table 7 captures a representative sample of task requirements (grouped by Duty Area) from the occupational specification for an Artillery Officer (DND, 1996) and Armoured Officer (DND, 1998) that are applicable to the MMEV Troop Leader. The competencies for the MMEV Troop Leader draw upon competencies traditionally associated with both occupations. There does not exist a one-to-one mapping between the MMEV Troop Leader and an existing job within the Combat Arms career field. To that end, the existing officer career paths for one or more occupations related to the Combat Arms would have to be restructured to accommodate the MMEV Troop Leader thereby creating a set of new HV-2 architecture products for this career field. Modelling different options for the TO-BE state allows the decision makers to assess the different options for answering questions of interest. For instance, should the MMEV Troop Leader job be added to the Armoured or Artillery career stream? Would it be a new career stream and/or replace an existing career stream? In turn, decision makers can also target the necessary individuals in the career progression streams to support IOC for the MMEV.

A similar comparative analysis for the MMEV CC, DCC, and Driver against NCM jobs within each of the three occupations under the Combat Arms career field would result in similar findings.

Table 7: Armoured and Artillery Officer Tasks Pertinent to MMEV Troop Leader.

Armoured Officer		**Artillery Officer**	
	DUTY AREA A – ADMIN (GENERAL)		**DUTY AREA A – ARTILLERY (ARTY) ADMIN (GENERAL)**
AT001	Maintain a troop leader's note book	AT001	Maintain a Troop Commander's note book
AT002	Inspect environmental equipment for serviceability	AT002	Maintain gun history books
AT003	Coordinate replenishment	AT003	Inspect Field Artillery equipment
AT004	Request repair and recovery of vehicles	AT004	Direct Field Artillery equipment maintenance
	DUTY AREA B – OPERATIONS (GENERAL)	AT006	Inspect AD artillery equipment
BT001	Select ground of tactical importance	AT007	Direct AD equipment maintenance
BT002	Determine enemy approaches		**DUTY AREA B – ARTILLERY OPS (GENERAL)**
BT006	Assess tactical situation from traces and orders	BT001	Conduct time estimate
BT007	Produce a surveillance and target acquisition plan	BT003	Crew command an armoured fighting vehicle (AFV)
BT012	Plan for indirect fire support	BT006	Employ fire support coordination measures
	DUTY AREA C – OFFENSIVE OPERATIONS	BT011	Analyze arty intelligence and information
CT001	Employ fire and movement within a troop	BT012	Disseminate arty intelligence and information
CT003	Conduct a troop advance		**DUTY AREA C – OFFENSIVE OPERATIONS**
CT005	Select vehicle positions for fire or observation	CT001	Advise on AD matters during the planning of an attack
CT006	Conduct combined arms offensive operations	CT002	Conduct the AD battle during an attack
CT015	Conduct an attack	CT003	Conduct tactical assembly area drills
CT016	Employ infantry-tank target indication procedures	CT004	Employ local AD drills
CT027	Employ fire support coordination measures	CT006	Conduct the AD battle during the advance
CT036	Conduct flank security operations	CT008	Conduct the AD battle during the pursuit
	DUTY AREA D – DEFENSIVE OPERATIONS		**DUTY AREA D – DEFENSIVE OPERATIONS**
DT002	Conduct combined arms defensive operations	DT002	Conduct the AD battle during a hasty defence
DT005	Conduct covering force operations	DT004	Conduct the AD battle during a deliberate defence
DT011	Establish a track plan	DT010	Conduct the AD battle during covering force operations
DT015	Conduct a deliberate defence for a troop	DT012	Conduct the AD battle during counter-move operations
DT017	Layout a troop/infantry defensive position		**DUTY AREA E – FIELD GUNNERY**
DT018	Site tanks in fire positions	ET001	Recce gun positions
DT019	Select defensive fire targets	ET002	Direct the deployment of the battery position
DT020	Conduct blocking operations	ET003	Formulate battery survey plan
DT021	Conduct a counter-attack	ET004	Conduct Battery Survey

Armoured Officer		Artillery Officer	
	DUTY AREA E – ARMOUR GUNNERY	ET005	Prepare for the engagement of targets with indirect fire
ET001	Crew command an AFV	ET006	Engage targets with direct and indirect fire
ET002	Engage target with AFV main armament	ET007	Supervise gun line operations
ET006	Operate AFV ancillary equipment		**DUTY AREA F – AIR DEFENCE**
ET008	Operate AFV multi-barrel smoke grenade dischargers	FT001	Advise Commander on AD
ET010	Operate observation devices	FT002	Perform the duties of an AD Liaison Officer
ET013	Operate hand held laser range devices	FT003	Deploy AD Artillery systems
ET014	Operate surveillance devices	FT004	Control AD fire
	DUTY AREA G – COMMUNICATIONS	FT005	Operate an Airspace Coordination Centre
GT001	Employ emission control measures	FT006	Implement airspace control orders and measures
GT002	Perform anti-jamming drills		**DUTY AREA G – COMMUNICATIONS**
GT003	Monitor communications network	GT001	Control a radio net
GT004	Control a radio net	GT002	Monitor communications
	DUTY AREA H – EXERCISES AND RANGES	GT004	Direct op. maintenance of communications equipment
HT001	Plan a field training exercise (FTX)		**DUTY AREA H – RANGES AND EXERCISES**
HT002	Conduct field firing exercises	HT001	Conduct a range practice
HT004	Conduct field training	HT003	Execute duties of range safety officer
HT002	Employ simulator systems	HT004	Prepare exercise instructions
	DUTY AREA I – TRAINING ADMINISTRATION		**DUTY AREA I – SPECIAL OPERATIONS**
IT001	Prepare course reports	IT002	Conduct the AD battle during an airmobile operation
IT002	Request training facilities, vehicles and equipment	IT003	Conduct Internal Security (IS) operations

6.4.4 Training

Given the tight coupling between the architecture products for career progressions (HV-2) and training (HV-3), the required changes to the existing career streams to accommodate the MMEV has a similar ripple effect on the existing training strategies. As such, the impact of MMEV would require resolution to training-related questions such as:

1. What training courses must be re-structured and/or introduced to accommodate the new system? What is the associated cost?

2. Will training be at the individual, crew/team, or unit level?

3. Does the flow of personnel through the training pipeline support the new system?

The training model will have to adapt for aspects of the army capability where complex weapons systems are staffed by small but highly trained teams. For instance, requiring the Driver to be cross-trained as an FCS operator is a significant shift from previous armoured crew concepts whereby armoured drivers were relatively junior with minimal FCS experience. Similar to the HV-2 architecture product, training streams are unique for officers and NCMs within each occupation of a given career field.

Figure 28 and Figure 29 illustrate the training roadmaps for an Armoured Officer (MOSID 00178) and an Armoured Crewman NCM (MOSID 00005) within the AS-IS regimental system.

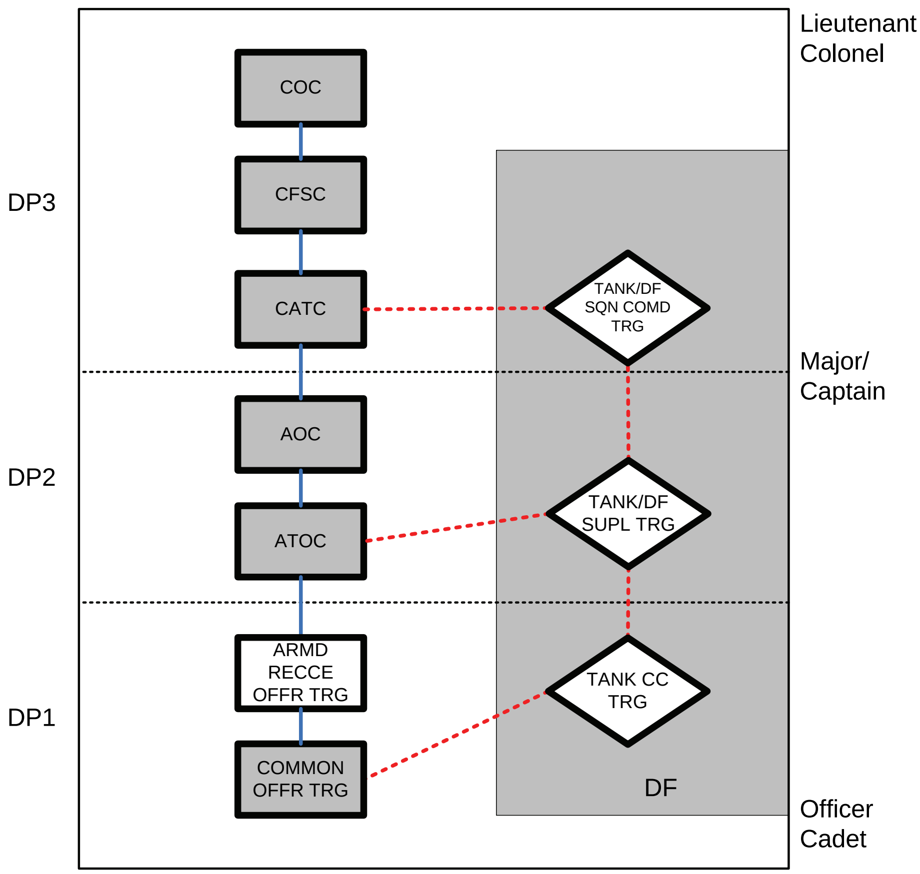

Figure 28: HV-3 Architecture Data Product for Armoured Officer (AS-IS)

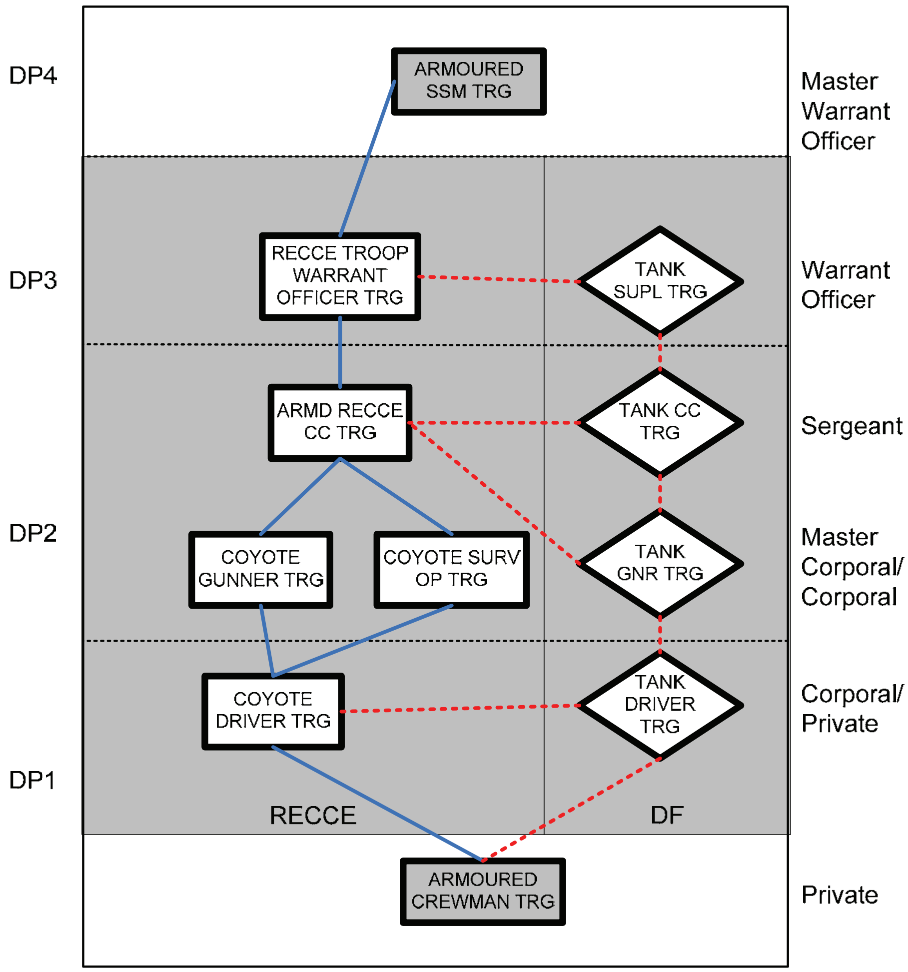

Figure 29: HV-3 Architecture Data Product for Armoured Crewman (AS-IS)

To support the training requirements imposed by any new system, training personnel (e.g., Directorate of Army Training) generate hierarchical scalars for a given job to illustrate performance objectives (PO) and their subsequent decomposition into lower level tasks (This decomposition is identical to a traditional decomposition of functions into tasks as typically conducted by HF personnel as part of a MFTA). The resulting task inventory would be compared to the current occupational specification for a MOSID in order to determine a "train/no train" disposition. The "no train" results indicate tasks that are not currently supported by existing training programs (i.e., gaps) and would need to be investigated further to determine a resolution. Table 8 illustrates a sample 'train/no train' matrix for the MMEV Troop Leader whereby a subset of the tasks, skills, and knowledge, from the MMEV TDP MFTA would be compared against existing training courses. A 'T' indicates competencies that are covered within existing training courses whereas 'NT' indicates a lack of sufficient training for the competency. The remarks field indicates the particular course satisfying the requirement.

Again, a similar comparison for the remaining MMEV crewmembers would also be conducted.

Table 8 : MMEV Troop Leader Train/No Train Matrix.

Serial	Requirement	T-NT	Remarks
TASKS			
	Configure Radio	T	Army Course ID #
	Configure Data Network	T	Army Course ID #
	Configure Local Situational Awareness System	NT	Existing course not sufficient
	Configure DAS Sensors	T	Army Course ID #
	Configure IR Sensor	T	Army Course ID #
	Configure Radar Sensor	NT	Existing course not sufficient
	Configure Combat ID Sensor	T	Army Course ID #
	Configure Fire Suppression System Sensor	NT	Existing course not sufficient
	Configure DAS Counter-Measures	T	Army Course ID #
	Define Search Field	T	Army Course ID #
	Activate Search Aid	T	Army Course ID #
	Perform Search	T	Army Course ID #
	Perceive Contact Signatures	T	Army Course ID #
	Perceive Number of Contacts	T	Army Course ID #
	Perceive Contact Signatures	T	Army Course ID #
	Determine Range to Contact	T	Army Course ID #
	Determine Absolute/Relative Position of Contact	T	Army Course ID #
	Assess Contact Capabilities	T	Army Course ID #
	Classify Contact Threat Priority	T	Army Course ID #
SKILLS			
	Firing AFV armaments	T	Army Course ID #
	Crew commanding	T	Army Course ID #
	Preparing range cards	T	Army Course ID #
	Using voice procedures	T	Army Course ID #
	Siting communications equipment	T	Army Course ID #
	Map marking	T	Army Course ID #
	Applying battle drills	T	Army Course ID #
	Identifying AFV and aircraft	T	Artillery Course ID #
	Coordinating direct fire	T	Armoured Course ID #
	Locating the enemy	T	Army Course ID #
	Operating an Artillery CP	T	Artillery Course ID #
	Operating Artillery equipment	T	Artillery Course ID #
	Applying Artillery fire discipline	T	Artillery Course ID #
	Controlling Artillery fire	T	Artillery Course ID #

Serial	Requirement	T-NT	Remarks
	Assessing Artillery weapons effects	T	Artillery Course ID #
	Deploying an Artillery gun battery	T	Artillery Course ID #
	Applying principles of AD operations	T	Armoured Course ID #
KNOWLEDGE			
	Covering force operations	T	Army Course ID #
	Counter move operations	T	Army Course ID #
	Machine gun drills	T	Armoured Course ID #
	Radio nets	T	Army Course ID #
	Observation techniques	T	Artillery Course ID #
	Direct/indirect fire coordination techniques	T	Artillery Course ID #
	Artillery battle procedure	T	Artillery Course ID #
	Artillery deployment procedures	T	Artillery Course ID #

In the case of the MMEV Troop Leader, the training analysis may indicate the need to provide course work from different occupations as well as areas whereby new course material needs to be created to address gaps. Studying the AS-IS HV-3 architecture products for the Combat Arms career field illustrates the lack of an existing training scheme to address this situation. Identifying the training gaps is a necessary prerequisite prior to devising a solution. To that end, potential training strategies for the TO-BE state including the MMEV operators can be modelled (through the HV-3 architecture product) to determine a suitable resolution.

Understanding the training process depicted by the HV-3 architecture product helps to address the longer term requirements for ensuring that adequate individuals are trained and prepared for MMEV operation upon its introduction into the CF. For instance, the new roles of MMEV CC, DCC, and Driver may impose a lengthy training process to ensure these individuals possess the necessary KSA to command and operate the vehicle. As such, any training strategy will have to be proactive in order to compensate for the lengthy training process. The HV-2 would help to support the identification and resolution of these longer term issues.

While the individual training needs are partially addressed by existing processes (and HVs), the role of the MMEV within the larger S-of-S concept (i.e., combat arms team) will impact the collective training needs which are captured within Battle Task Standards—another potential area of exploration for HVs with respect to training.

7 Conclusions and Next Steps

7.1 Initial HV Work

The conceptual approach to developing HVs to advance adequate visibility of the 'human' aspect of a capability within CE was first introduced as part of the HV Concept Paper (Pogue, Baker, & Pagotto, 2005). The report served as a departure point for subsequent development and listed a series of additional activities and objectives, including:

1. the establishment of a Human View Working Group with participation by key stakeholders to provide additional focus and support for the subsequent HV development in a guidance and oversight capacity;

2. the identification of a Human View 'champion' within DND/CF to leverage on-going CE work within CapDEM to support the institutionalization of Capability Engineering inclusive of adequate 'human' visibility within Capability-based decision analysis;

3. additional study and development of HVs to extend and validate the concepts described in this report, including Human View application in select 'use cases';

4. review and assess existing analysis tools and processes for HR-related decision support for their suitability to develop Human Views within a CE analysis domain functioning at the S-of-S level and consider their incorporation into the developing CE tool suite requirements (e.g., a Director General Strategic Planning [DGSP] contracted System Dynamics model which included recruiting rates and the influence of various policy decisions for conduct of Ops, various software tools, etc.);

5. analyse the impact and integrate HVs into evolving Capability Engineering Process (CEP) developments; and,

6. analyse and integrate/align HVs developments within existing HR-related initiatives (e.g., managed readiness, etc.).

7.2 Current HV Work

As an extension to the original HV work, the activities and results presented in this report have progressed to ensure that CE adequately addresses the people component in both method and substance. In this respect, a limited set of Human Views have been developed as a 'test case' thereby exploring where they fit in CE and DoDAF, and generally how they support decision making within CBP at the program/capability level. The outcome of this effort demonstrates that HVs, from a conceptual standpoint, 'work' as they provide a suitable mechanism to embed I into CBP decision making and allow for the appropriate consideration of human implications which are on the critical path to any change in capability.

7.3 Future HV Work

Continued investigation of Human Views requires follow on work to:

1. Introduce newly updated DoDAF to Directorate of Capability Planning to assess whether it can be used as intended;

2. Map HVs to acquisition processes within DND (similar to JCIDS mapping);

3. Explore tools to directly support the creation of HVs;

4. Assess HVs for Force Development by CFD to embed personnel related fields;

5. Extend HVs to include additional architecture data products to address other human elements (HV Concept Paper [Pogue, Baker, & Pagotto, 2005] proposed other HVs); and

6. Collaborate with the international community to explore compatibility with similar HV research being conducted in the US and UK.

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List of symbols/abbreviations/acronyms/initialisms

AD	Air Defence
ADATS	Air Defence Anti-Tank System
ADM(IM)	Assistant Deputy Minister (Information Management)
AFV	Armoured Fighting Vehicle
AOA	Analysis of Alternatives
AOC	Army Operations Course
ARTY	Artillery
ATOC	Army Tactics and Operations Centre
AV	All Views
BOTC	Basic Officer Training Course
BTL	Basic Training List
C2	Command and Control
CADM	Core Architecture Data Model
CapDEM	Collaborative Capability Definition, Engineering, and Management
CC	Crew Commander
CDD	Capability Development Document
CPD	Capability Production Document
CE	Capability Engineering
CEP	Capability Engineering Process
CF	Canadian Forces
CFD	Chief Force Development
CFITES	Canadian Forces Individual Training and Education System
CFSC	Canadian Forces Staff College
CJSC	Chairman of the Joint Chiefs of Staff
CMP	Chief of Military Personnel
COC	Commanding Officers Course
DADM	DND Architecture Data Model
DAOD	Defence Administrative Orders Directive
DCC	Deputy Crew Commander

DF	Direct Fire
DGSP	Director General Strategic Planning
DNDAF	Department of National Defence Architecture Framework
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities
DP	Development Period
DPGR	Director Personnel Generation Requirements
FAA	Functional Area Analysis
FCS	Fire Control Systems
FD	Field
FNA	Functional Needs Analysis
FOC	Final Operational Capability
FOO	Forward Observation Officer
FSA	Functional Solution Analysis
GBAD	Ground Based Air Defence
GS	General Specification
HR	Human Resources
HSI	Human Systems Integration
HV	Human View
ICD	Initial Capabilities Document
IOC	Initial Operating Capability
ISR	Intelligence, Surveillance, and Reconnaissance
IT&E	Individual Training and Education
IV	Information View
JCD	Joint Capabilities Document
JCIDS	Joint Capabilities Integration and Development Status
JROC	Joint Requirements Oversight Council
KSA	Knowledge, Skills, and Abilities
LF	Land Forces
LOS	Line of Sight
MBT	Main Battle Tank

MFTA	Mission, Function, Task Analysis
MGS	Mobile Gun System
MoDAF	Ministry of Defence Architectural Framework
MOS	Military Occupational Structure
MOSART	Military Occupational Structure Analysis, Redesign, & Tailoring Project
MOSID	Military Occupational Structure Identification
MMEV	Multi Mission Effects Vehicle
MRCV	Multi-Role Combat Vehicle
NCM	Non-Commissioned Member
NEF	Non-Effective Force
NLOS	Non Line of Sight
NOC	National Occupational Classification
OCdt	Officer Cadet
OMI	Operator Machine Interface
OS	Occupational Specification
OSS	Occupational Specialty Specification
OV	Operational View
PIA	Post Independent Analysis
PO	Performance Objective
PRICIE	Personnel, R&D and Operations Research, Infrastructure and Organization, Concepts, Doctrine and Collective Training, IT Infrastructure, Equipment
P Res	Primary Reserve
PSR	Projected Status Report
Pte	Private
Recce	Reconnaissance
Reg F	Regular Forces
RSM	Regiment Sergeant Major
SCIP	Strategic Capability Investment Plan
SCP	Strategic Capability Planning
SecV	Security View
S-of-S	Systems-of-Systems
Spec F	Special Forces
SSM	Squadron Sergeant Major

StV	Strategic View
SUTL	Subsidized University Training List
SV	Systems and Services View
TAD	Target Audience Description
TDP	Technology Demonstration Project
TEE	Trained Effective Establishment
TES	Total Effective Strength
TPS	Total Paid Strength
TUA	Tow Under Armour
TSV	Technical Standards View
UJTL	Universal Joint Task List

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The Collaborative Capability Definition, Engineering and Management (CapDEM) Technology Demonstration Project (TDP) has been exploring the concept of Capability Engineering (CE) which provides analytical rigour and traceability within a “System-of-Systems (S-of-S)” construct to support the execution of Capability Based Planning (CBP). CapDEM has invested significant effort into the integration of specific tools and processes to support CE and its relationship to the Defence Management System. Within this effort, the utility of the Department of Defense Architecture Framework (DoDAF) has been highlighted. Specifically, DoDAF assists the overall system design, evolutionary acquisition and interoperability within the US Joint Capabilities Integration and Development System (JCIDS), which is used to determine military capability requirements.

A component of a capability that has increasingly drawn attention within the CapDEM team is how best to represent the human aspect of a capability within the S-of-S construct. DoDAF also has been recognized as lacking a suitably dominant human perspective. To that end, the concept of Human Views (HVs), which leverage Human System Integration (HSI) principles, has emerged.

The activities and results presented in this report have progressed to ensure that Capability Engineering adequately addresses the people component in both method and substance. In this respect, the following activities have been completed:

1. A subset of Human Views, addressing the manpower, career progression, and training domains, have been developed as a 'test case' thereby demonstrating where they fit in CE and generally how they support decision making within CBP at the program/capability level;

2. A direct relationship to an on-going Human Resources (HR)-related activity (Military Occupation Structure Analysis, Redesign and Tailoring [MOSART]) has been established; and

3. An application of the Human Views to a military system acquisition (Multi-Mission Effects Vehicle [MMEV]) has been explored.

The outcome of this effort demonstrates that HVs do indeed ‘work’ as they fit with the current US JCIDS framework and therefore should theoretically fit within the DND acquisition process. In addition, HVs provide a suitable mechanism to embed HSI into CP-based decision making and ensure a significant cost driver is addressed ‘up front’.

Le Projet de démonstration de technologie (PDT) intitulé « Définition, ingénierie et gestion collaborative de capacités » (DIGCap) a examiné le concept d’ingénierie des capacités (IC), qui apporte rigueur analytique et traçabilité à la notion de « système de systèmes » (S de S) afin d’appuyer la planification fondée sur les capacités (PFC). Le DIGCap a investi beaucoup d’efforts dans l’intégration d’outils et de processus particuliers pour appuyer l’IC et sa relation avec le Système de gestion de la Défense. Dans le cadre de cette initiative, l’utilité du Cadre

d’architecture du département de la Défense des États Unis (DoDAF) a été soulignée. En particulier, le DoDAF appuie la conception globale, l’acquisition évolutive et l’interopérabilité des systèmes au sein du Système d’intégration et de développement des moyens interarmées (JCIDS) des États Unis, qui est utilisé pour établir les besoins en capacités militaires.

Ce qui intéresse de plus en plus l’équipe DIGCap, c’est de trouver le meilleur moyen de représenter l’aspect humain d’une capacité dans un S de S. L’équipe a également constaté que le DoDAF n’accorde pas la priorité à l’aspect humain. C’est pourquoi le concept de « vue humaine » (VH), qui fait appel aux principes de l’intégration homme machine (IHM), a émergé.

Les activités et les résultats présentés dans ce rapport initial ont été développés pour faire en sorte que l’ingénierie des capacités (IC) tienne compte adéquatement de l’élément humain dans ses méthodes et sa substance. À cet égard, les activités suivantes ont été menées à bien :

1. Un sous-ensemble de vues humaines (VH) portant sur la main d’œuvre, l’avancement professionnel et l’instruction a été élaboré pour servir de « cas type » et démontrer comment les VH sont utiles à l’IC et comment elles appuient, d’une façon générale, le processus de prise de décision lié à la PFC au niveau des programmes et des capacités.

2. Une relation directe avec une activité liée aux ressources humaines (RH) (Projet d’analyse, de restructuration et d’adaptation de la structure des groupes professionnels militaires [PARA]) a été établie.

3. Une application des VH à l’acquisition d’un système militaire (véhicules à effet multimission [VEMM]) a été examinée.

Le résultat de ces efforts montre que les VH « fonctionnent » réellement, car elles s’inscrivent parfaitement dans le cadre actuel du JCIDS des Etats-Unis. Par conséquent, en théorie, elles devraient bien s’intégrer au processus d’acquisition du MDN. De plus, les VH fournissent un mécanisme approprié pour intégrer l’IHM au processus de prise de décision lié à la PFC, et faire en sorte qu’un important « inducteur de coût » soit pris en considération.

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Human Views; DoDAF; Human Systems Integration; Capability Engineering